Constrained Parametric Min-Cuts for Automatic Object Segmentation

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Outline

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  - Experiments
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Overview

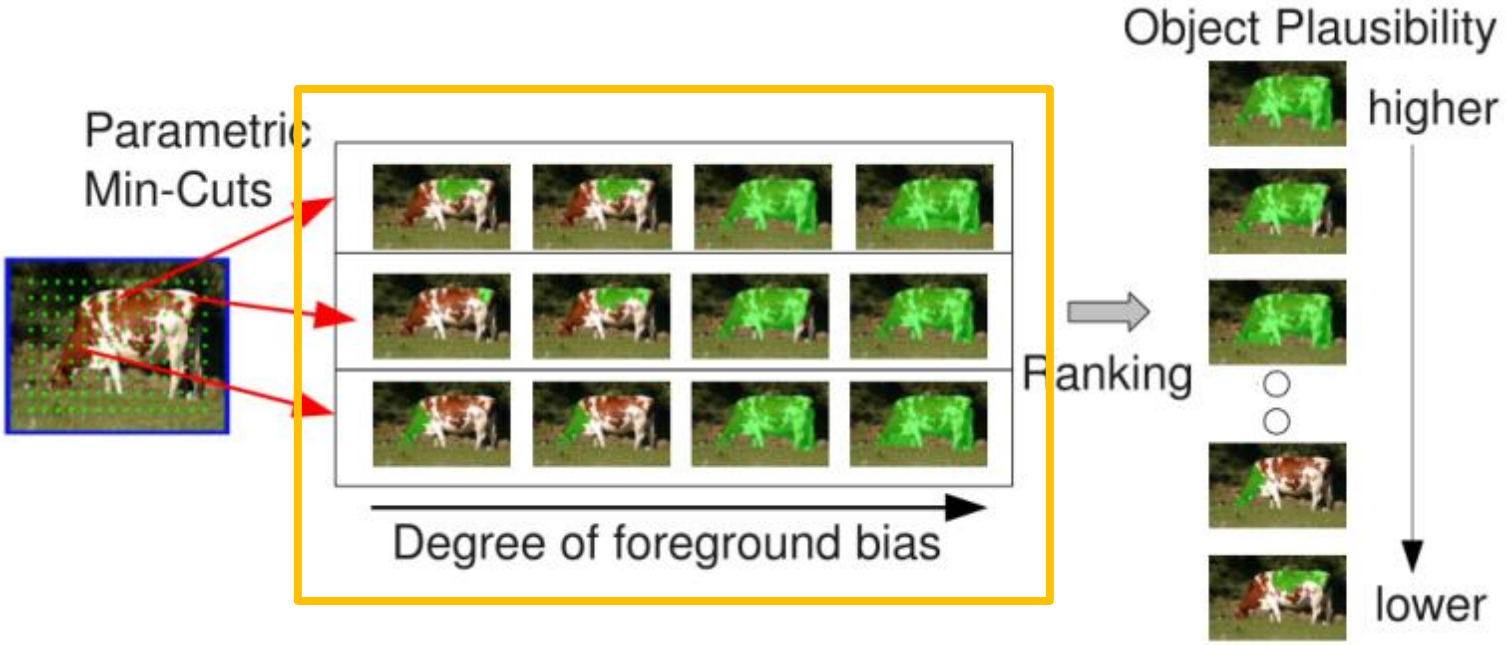


Figure credit: Joao Carreira *et al.*

Constrained Parametric Min-Cuts (CPMC)

- Graph-based segmentation algorithm
  - Similarity between neighboring pixels is encoded as edges.

$$E^{\lambda}(X) = \sum_{u \in V} D_{\lambda}(x_u) + \sum_{(u,v) \in E} V_{uv}(x_u, x_v)$$

$$V_{uv}(x_u, x_v) = \begin{cases} 0 & , \text{if } x_u = x_v \\ g(u,v) & , \text{if } x_u \neq x_v \end{cases}$$

$$g(u,v) = \exp\left[-\frac{\max\left(gPb(u), gPb(v)\right)}{\sigma^2}\right]$$

where gPb is the output of the multi-cue contour detector.

Constrained Parametric Min-Cuts (CPMC)

- Multi-Cue Contour Detector
  - Estimate the posterior probability of a boundary.

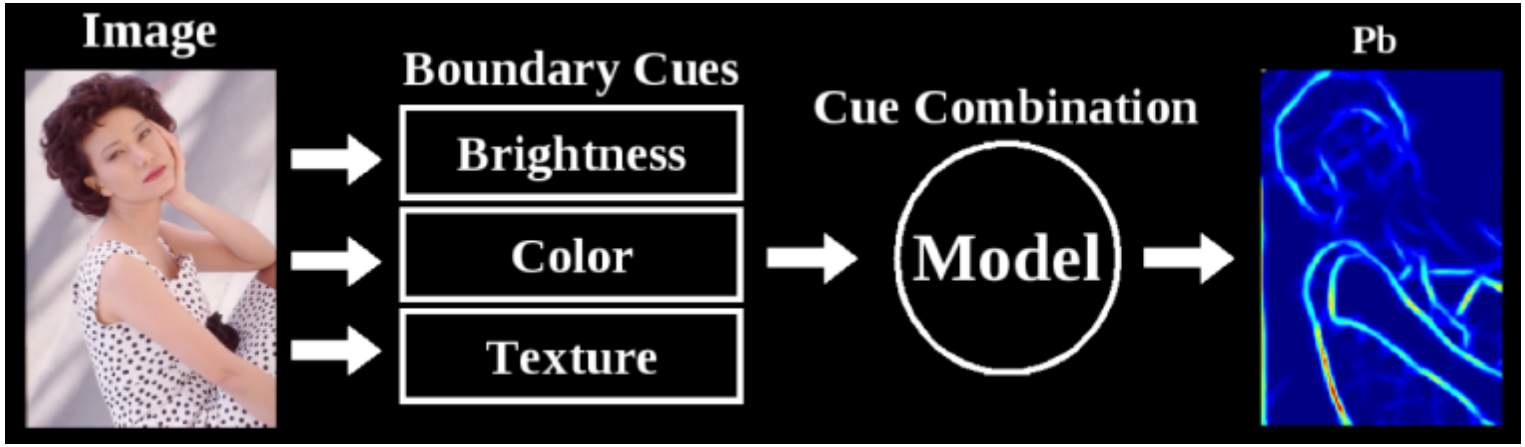


Figure credit: Michael Maire *et al.*

Experiments

- Segmentation Covering

$$C(S, S') = \frac{1}{N} \sum_{R \in S} |R| * \max_{R' \in S'} O(R, R')$$

$$O(R, R') = \frac{|R \cap R'|}{|R \cup R'|}$$

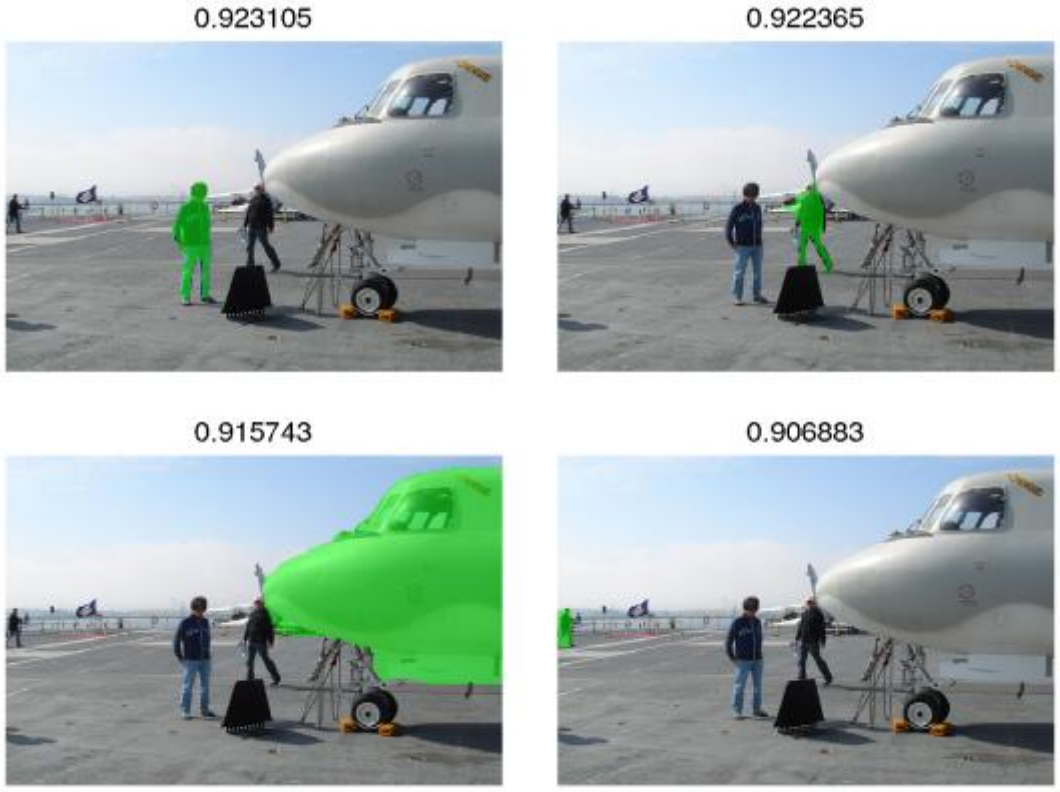
S : the ground-truth segmentation

S' : the object hypotheses

$|R|$: number of pixels in the ground-truth segment

Experiments

- Example Images



Experiments

- Example Images

Experiments – Distorted Images

- Will different distortions in images affect the segmentation performance?
- Will the distortion degrade the quality of the estimated posterior probability of boundary?

- LIVE Image Quality Database
  - Gaussian blur
  - JPEG compression
  - White noise

Test Images

Reference

Blur

JPEG

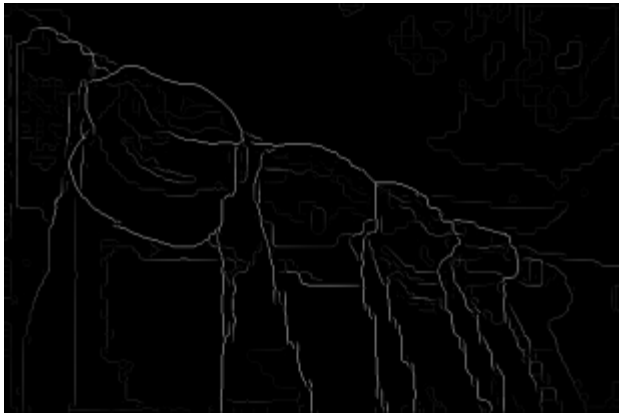
White Noise

Probability of Boundary Map

Reference

Blur

JPEG



White Noise

Experiments

- Reference






Experiments

- Blur

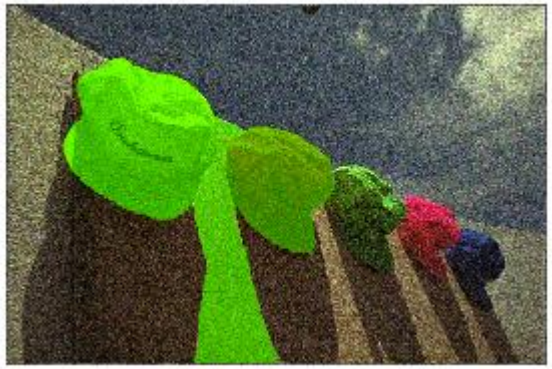
Experiments

- JPEG




Experiments

- White Noise

Ranking Object Hypotheses

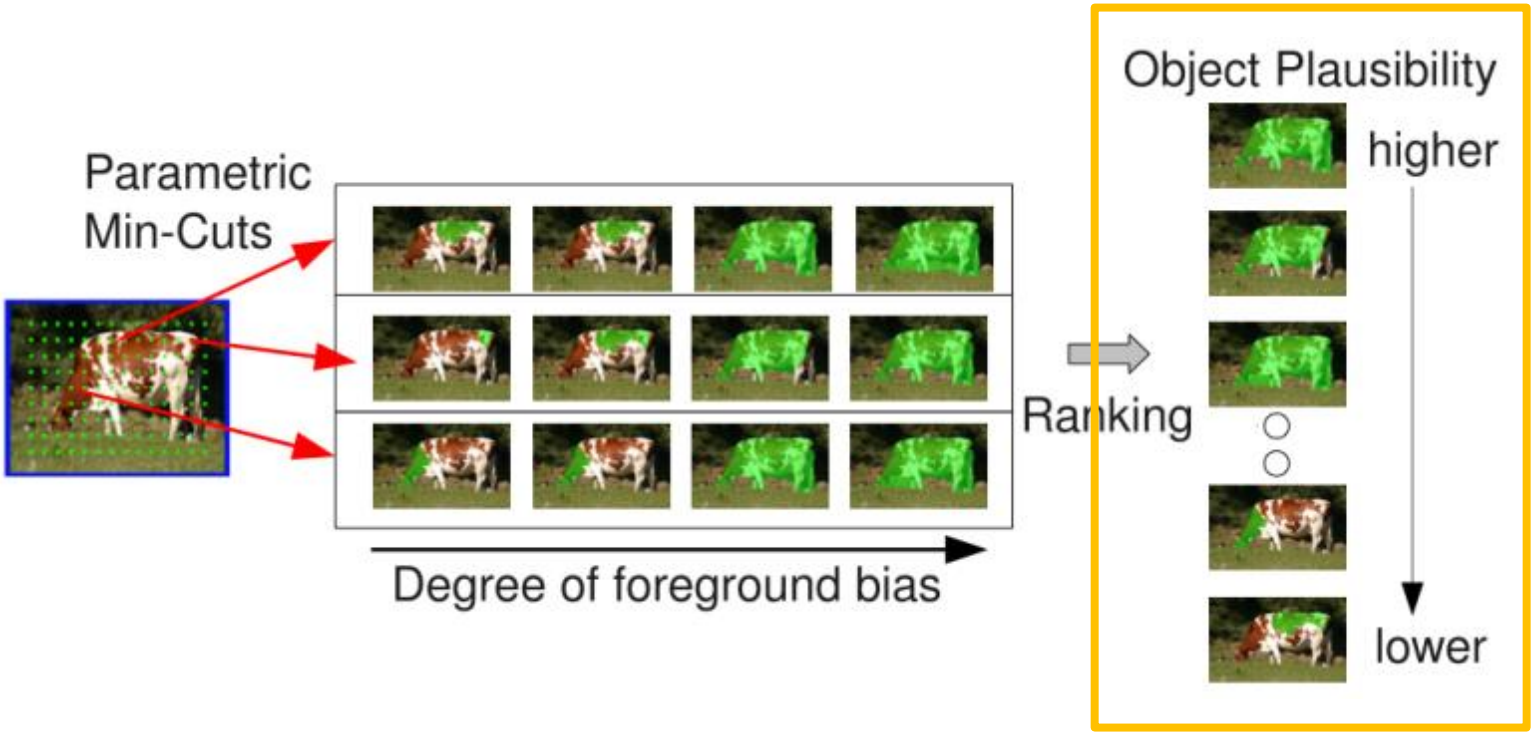


Figure credit: Joao Carreira *et al.*

Experiments

- Can depth cues help rank the object hypotheses?
  - Depth are continuous; however, objects can be seen as residing in different depth planes.

- Middlebury Stereo Datasets
  - Ground-truth disparity maps
- LIVE Color+3D Database
  - Ground-truth range maps

Experiments

- Append the feature with depth/disparity cues and retrain the ranking model with multiple linear regression.

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + ... + \beta_p x_{ip} \text{ for } i = 1, 2, ..., n$$

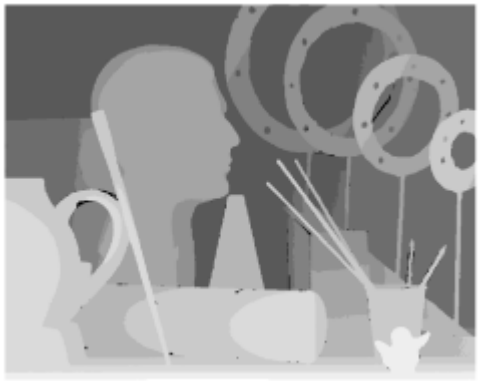
$$\begin{bmatrix} y_1 \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} x_{11} & \cdots & x_{1p} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{np} \end{bmatrix} \begin{bmatrix} \beta_1 \\ \vdots \\ \beta_p \end{bmatrix} + \beta_0$$

where $[x_{i1}, \cdots, x_{i(p-3)}]^T$ is the original feature vector containing graph partition, region, and gestalt properties,

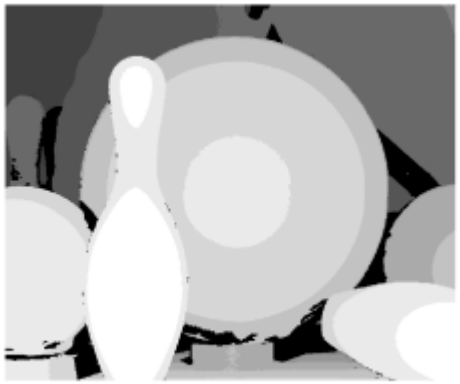
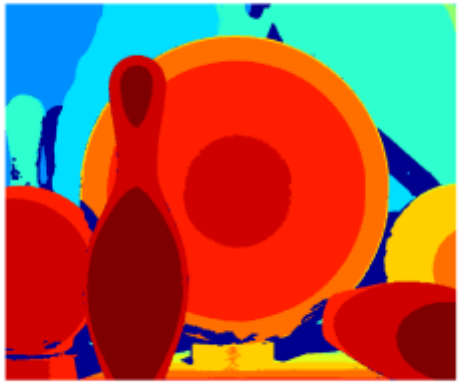
$[x_{i(p-2)}, x_{i(p-1)}, x_{i(p)}]^T$ is the appended feature vector containing depth STD, depth gradient mean, and depth gradient STD.

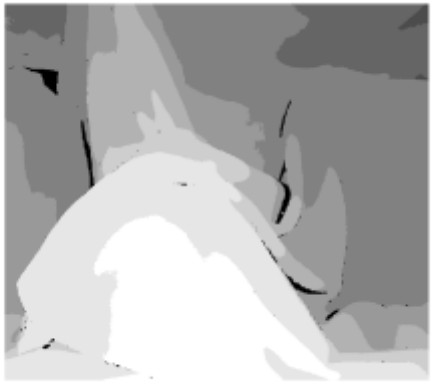
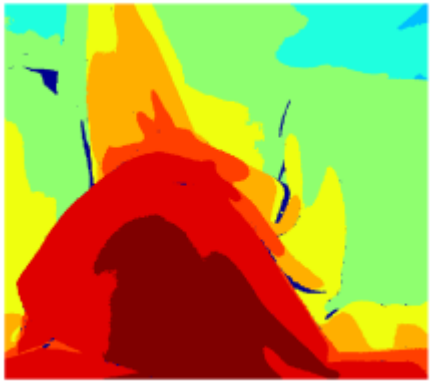
Experiments

- Middlebury Stereo Datasets
  - Indoor scenes with ground-truth disparity maps
  - Different types of objects
  - Ranking model is trained on LIVE Color+3D database.



Experiments

Original Features

New Features and Regressor

Original Features

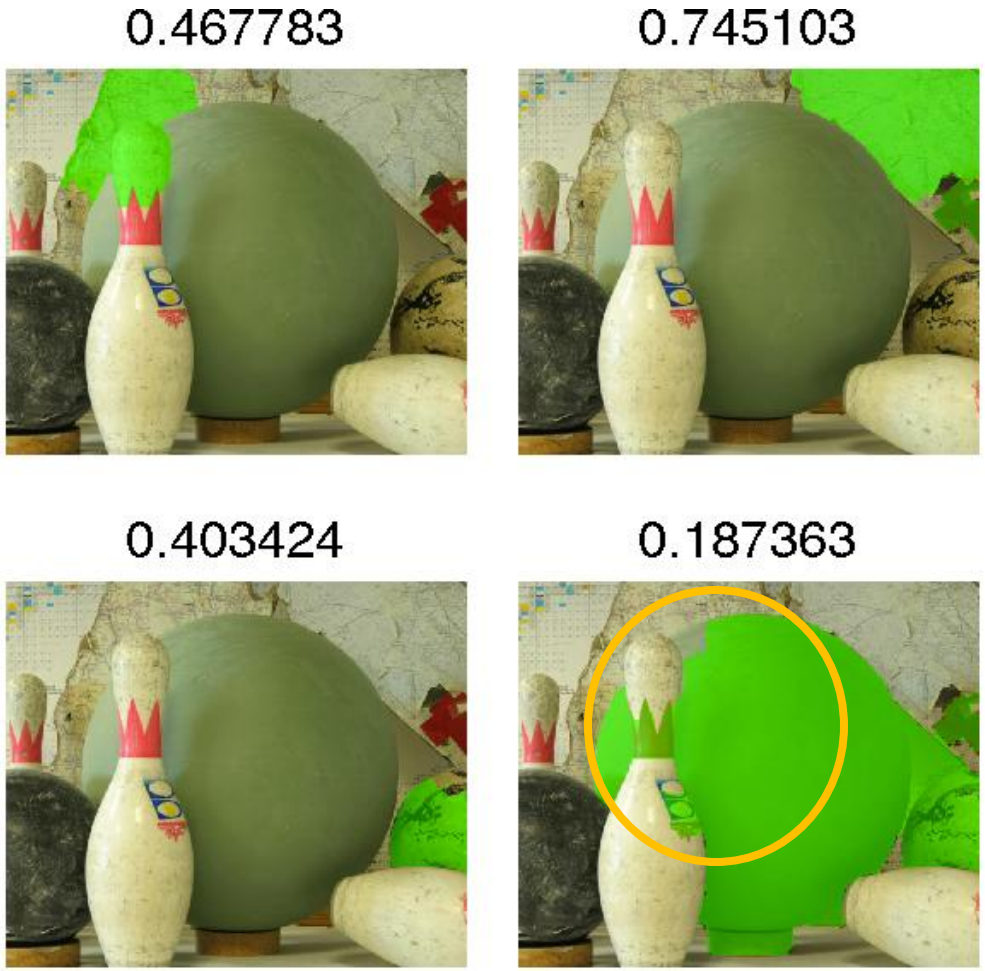
0.629228

0.745103

0.463812

0.191724

New Features and Regressor



Original Features

0.196388

0.452087

0.505323

0.615173

New Features and Regressor

0.196388

0.424314

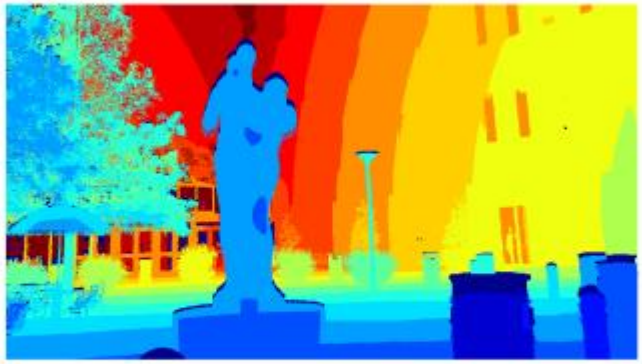
0.490003

0.450192

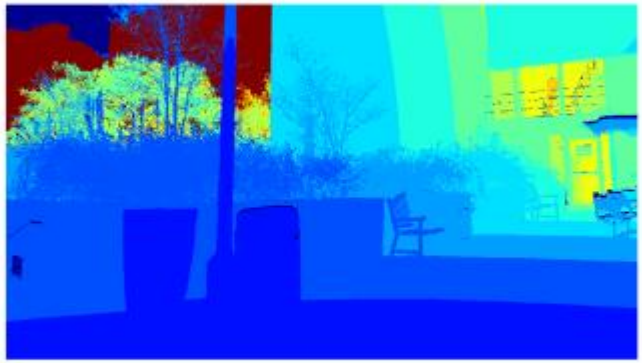
Experiments

- LIVE Color+3D Database
  - Natural scenes with ground-truth range maps
  - Quantize actual range values to generate depth planes.
  - Ranking model is trained on Middlebury stereo datasets.

Experiments



Experiments



Original Features

0.191496

0.338860

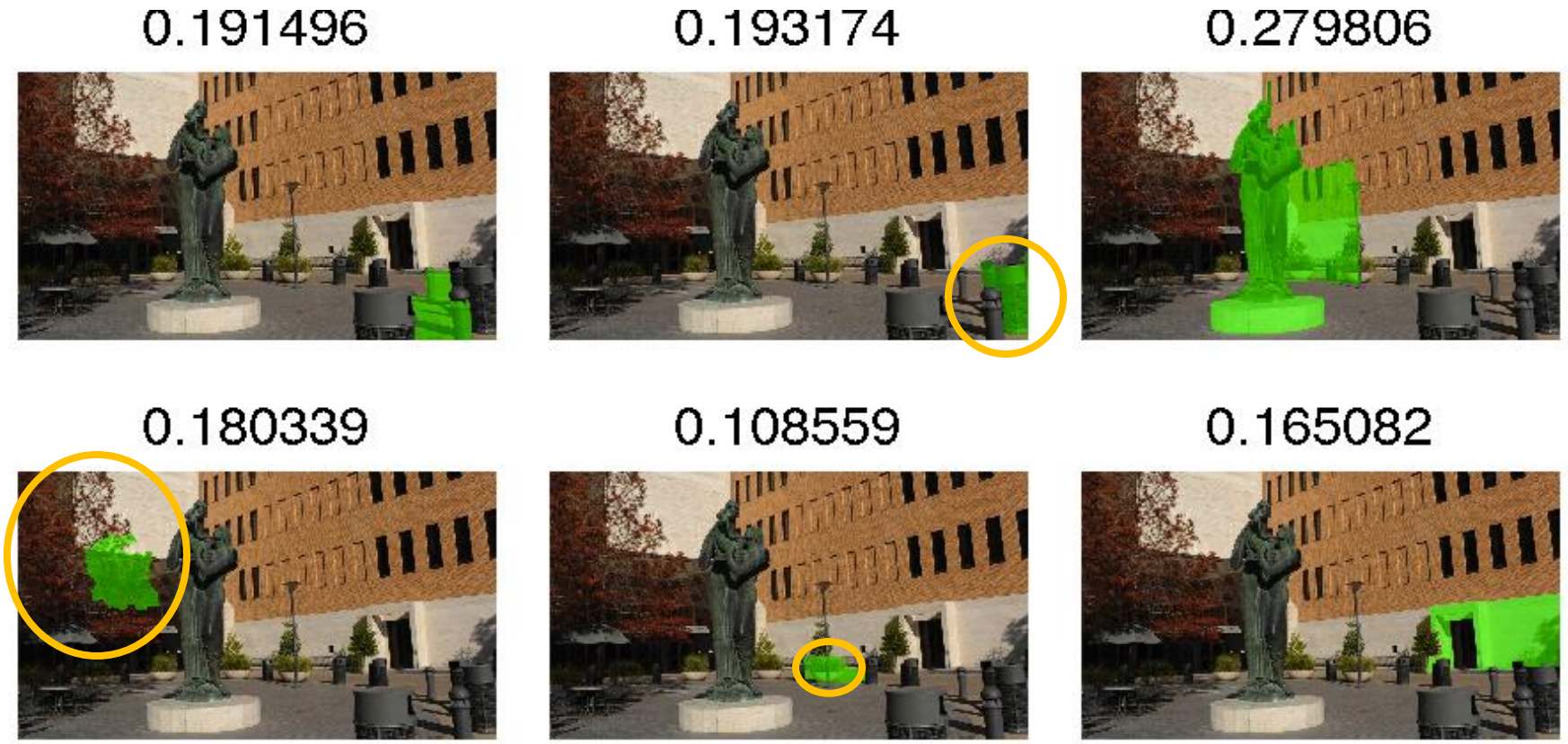
0.315339

0.251558

0.115919

0.165082

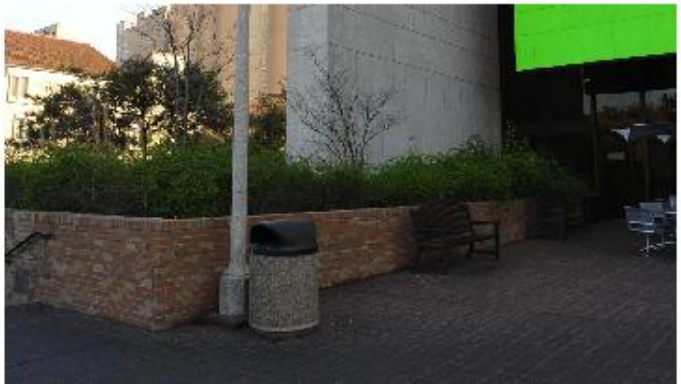
New Features and Regressor



Original Features

0.407832

0.337091



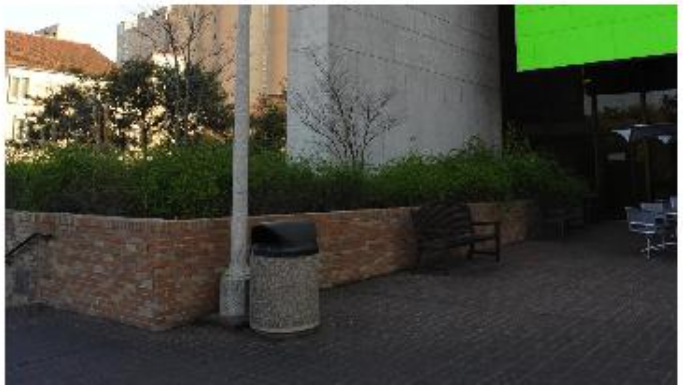
0.133830

0.187111

New Features and Regressor

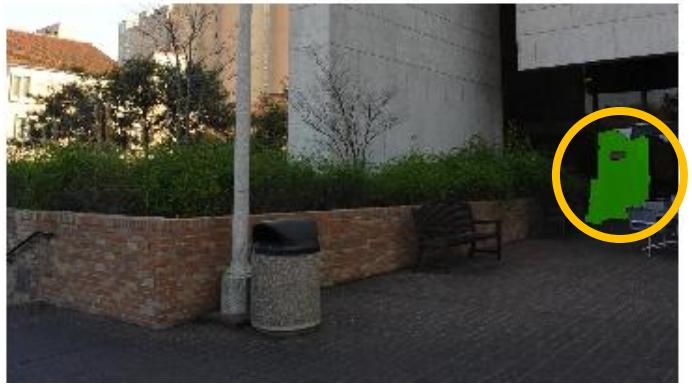
0.407832

0.333177



0.133830

0.179389



Discussion

- Different types of distortions in images can affect the segmentation results.
  - Probability of boundary map is distorted.
  - CPMC generates incorrect figure-ground (object) hypotheses.
- Ranking model can be governed by different types of segment features and properties.
  - Depth cues could possibly help recognize objects, and vice versa.