Introduction

- The Problem: (1) Model human clutter perception using proto-objects. (2) Estimate "set size" for realistic scenes.

- What is Visual Clutter? A "confused collection" or a "crowded disorderly state". Increasing visual clutter leads to poorer performance in many behavioral tasks (e.g. visual search).

- What is a Set Size Effect? A drop in search performance with an increase in the number of objects [1]. However, an object count is difficult to quantify in real-world scenes.

Set size and Proto-object Segmentation

- Object Complexity Effect:Bruce and Fardal, 2008 showed that compound objects negatively affected search time as compared to simple objects.

- Set size using Proto-objects: Not only that "objects" in the real world are ill defined concepts, Bruce and Fardal, 2008 showed that the number of object parts should also be taken into account, we find that the term proto-objects defined in [1] closely resembles both real-world simple objects, as well as object parts.

- The Proto-object clutter model: We propose to segment an image into proto-objects, namely image patches that have relatively uniform feature distribution (color), and using the normalized count of proto-objects as the clutter measure for an image.

- Our Proto-object Segmentation Method:
  - 1. Image partitioning using superpixel segmentation.
  - 2. Cluster similar superpixels into proto-objects, using Mean-shift clustering [6].
  - 3. Normalize the proto-objects count between 0 and 1, as our final clutter measure.

Dataset

- 90 800x600 real world images, sampled from the SUN Database [2].
- Divided into 6 groups, each with a different range of object counts (from SUN09).
- Clutter rankings (15 raters) and object segmentations (SUN) available for each image.
- Mean correlation between all pairs of human ranking: Spearman’s ρ = 0.6919

Left: 24 simple objects (uniform color).
Right: 24 compound objects (multiple parts with different colors).
Images from [8]

Experiments and Results

Method comparison: Spearman’s Correlations between human clutter perception and all the evaluated methods using our 90 image dataset.

- # of Objects and Clutter
- As shown in the method comparison table above, # of objects (human derived) was weakly correlated with our behavioral clutter rankers. This suggests that proto-objects may be a better representation of set size, instead of objects.

Contributions

- Clutter Model: Our model successfully predicts the degree that a person will perceive an image as cluttered, and out-performs all other existing models of clutter perception.
- Proto-object Segmentation: image partitioning using mean-shift clustering in the HSV color space, highly robust under different parameter settings.
- Clutter Dataset: We obtained a clutter ground truth by having people rank order a subset of images from SUN09 [1] from least to most cluttered.

References & Acknowledgment

Top: 51 color clusters found using Mean-shift in HSV.
Bottom: 47 color clusters found using Mean-shift in HSV.
Top: 200 proto-objects after merging superpixels of the same color cluster.
Bottom: 281 proto-objects after merging superpixels of the same color cluster.
Top: visualization of proto-objects, normalized clutter score = 0.345.
Bottom: normalized clutter score = 0.408.

Object segmentations from human observers for 4 of the 90 test scenes, r = 0.814.

Proto-object clutter score: 0.430
(ranked 47th vs 38th behaviorally)

Proto-object clutter score: 0.540
(ranked 69th vs 73rd behaviorally)

Proto-object clutter score: 0.632
(ranked 87th vs 89th behaviorally)

Method parameters: Entropy Rate k = 600 in HSV.