Texture and Color Distribution-based Classification for Live Coral Detection

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July 9, 2012

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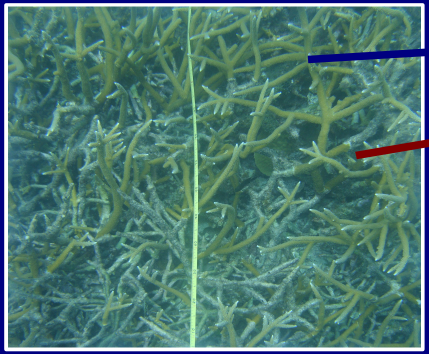
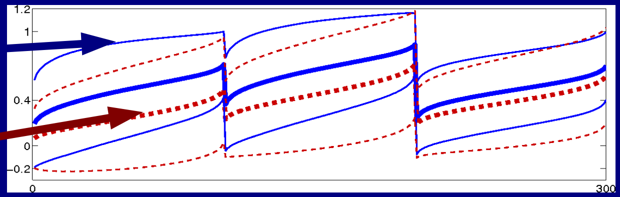
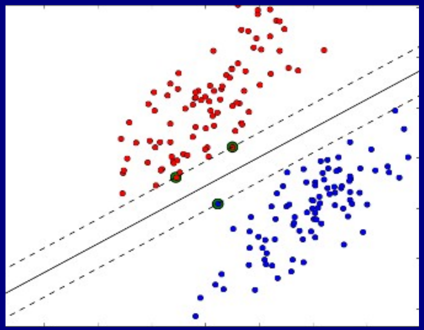
The Gist

- **Problem**: Estimate live *A. cervicornis* cover
- **Preliminary solution**: linear SVM on quantile functions

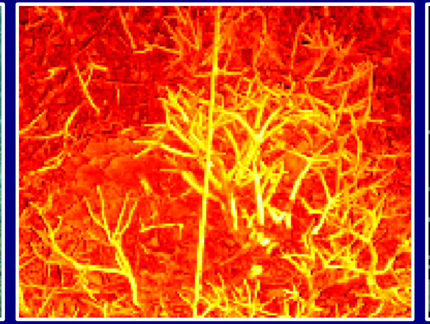
Train:

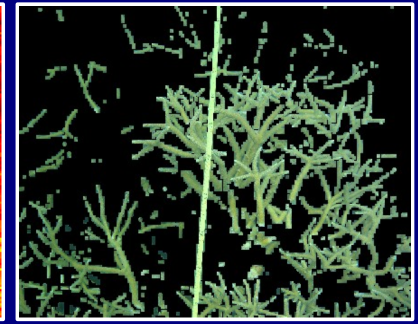






Test:

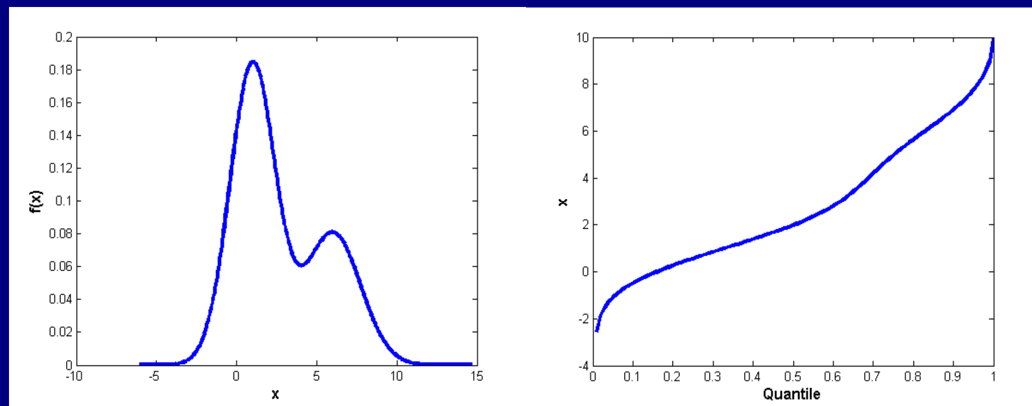




Prior Work

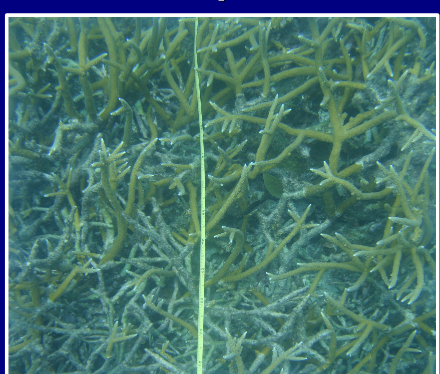
- Supervised Learning
  - Feature types: texture, color
    - SIFT, GIST, GLCM – [van de Sande et al., TPAMI 2010]
  - Discriminating learner
    - Support Vector Machines – [Cortes, Vapnik, ML 1995]
    - Random Forests – [Criminisi 2011]
    - Clustering, Fisher, Gaussian Mixtures, Neural Net, ...
- Coral benthic studies
  - NCC/LBP with NN – [Marcos et al., Optics 2005]
  - Filter bank response with BoW/clustering – [Purser et al., MEPS 2009], [Beijbom et al., CVPR 2012]
  - SVM on raw color – [Mehta et al., VISAPP 2007]

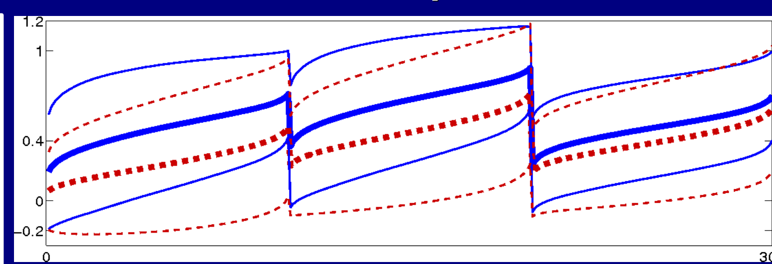
Features: Color Quantile Functions (QFs)



[Levina, UC-Berkeley 2002] [Broadhurst et al., ISBI 2006]

- Inverse cumulative distribution function
- Mean shift, variance scaling are linear
- Computed for each color channel at local patches





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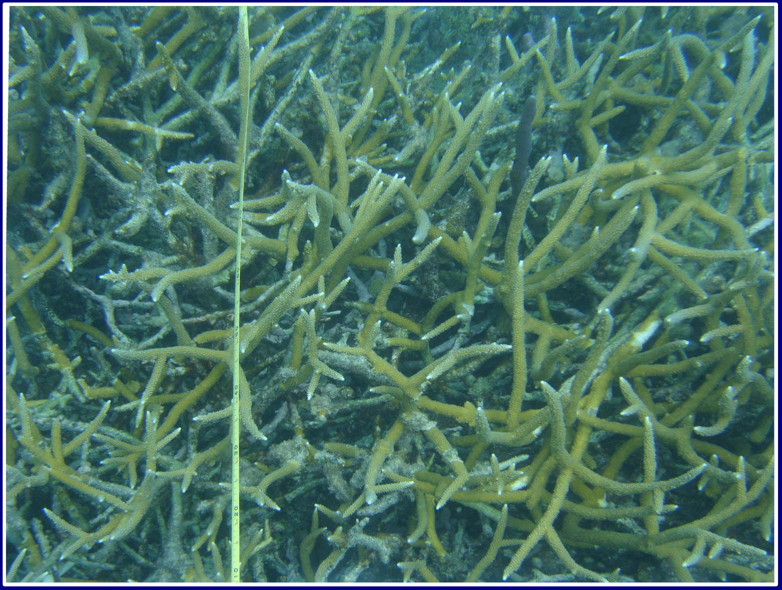
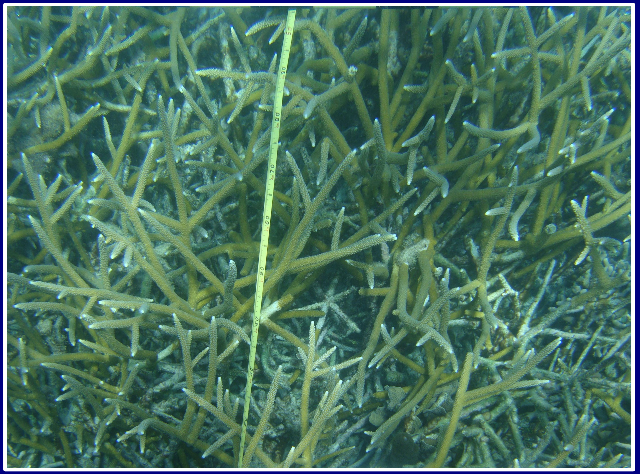
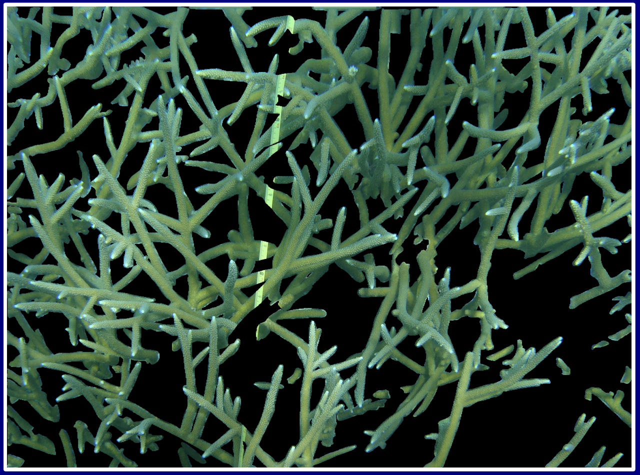
Experimental Setup

- 62 quadrat images
- Leave-one-out
- Each image/seg implies SVM classifier.
  - Use closest in average QF.



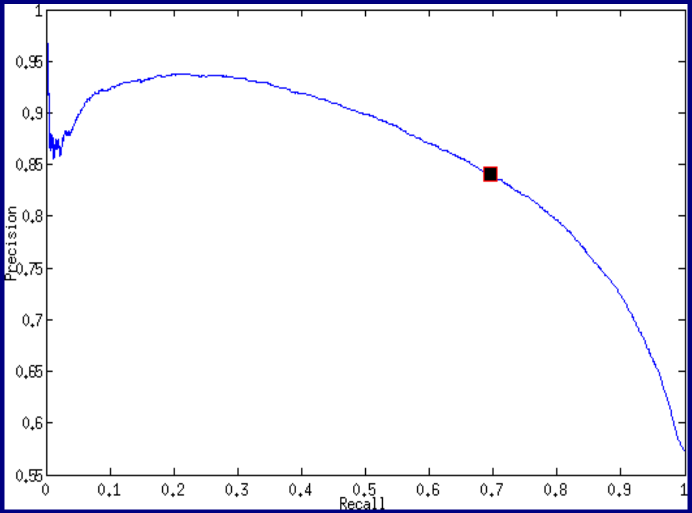
SVM



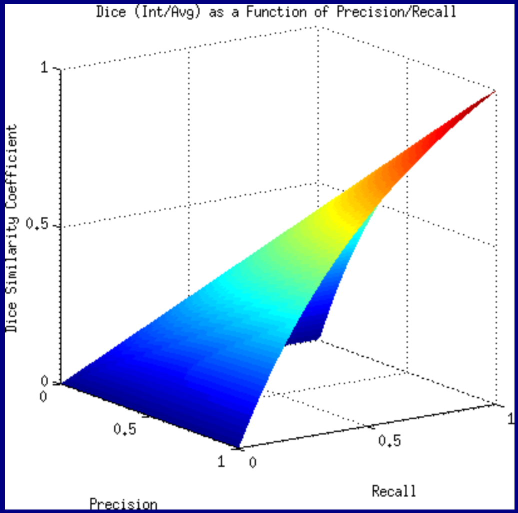


Validation

- Average Precision (AP) – area under the Precision/Recall curve
  - Biased (not infinitely many negatives)
- Dice Similarity Coefficient (DSC) – intersection with manual, divided by average.



Example PR curve



DSC vs. PR

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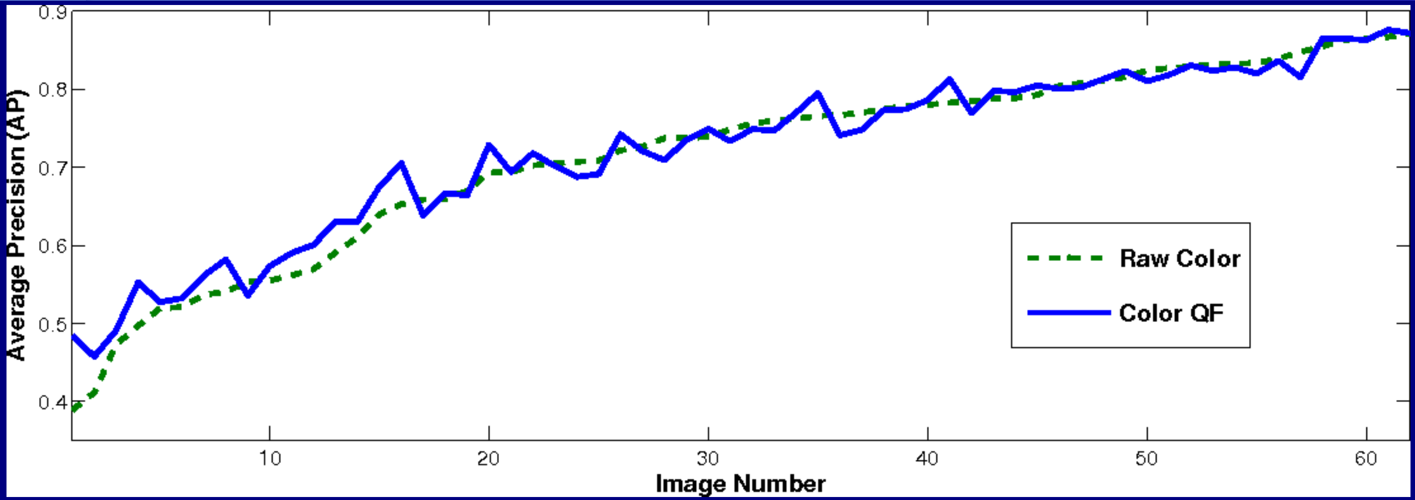
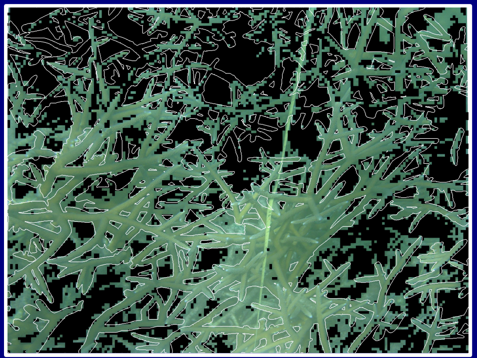
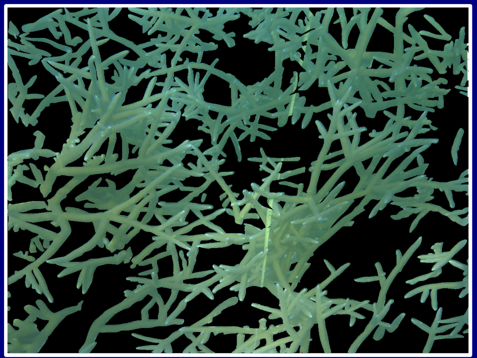
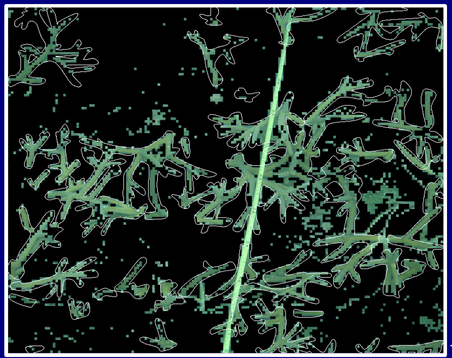
Results

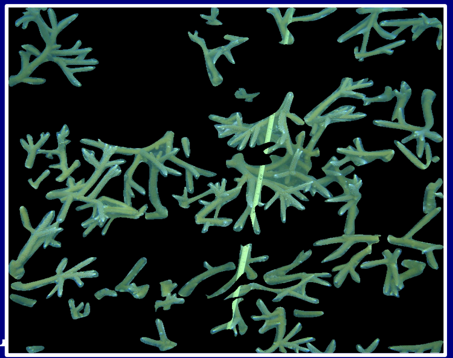


- AP: .721 QFs (vs .714 raw)
  - Figure: better by more, more often
- DSC: 63.8% overall

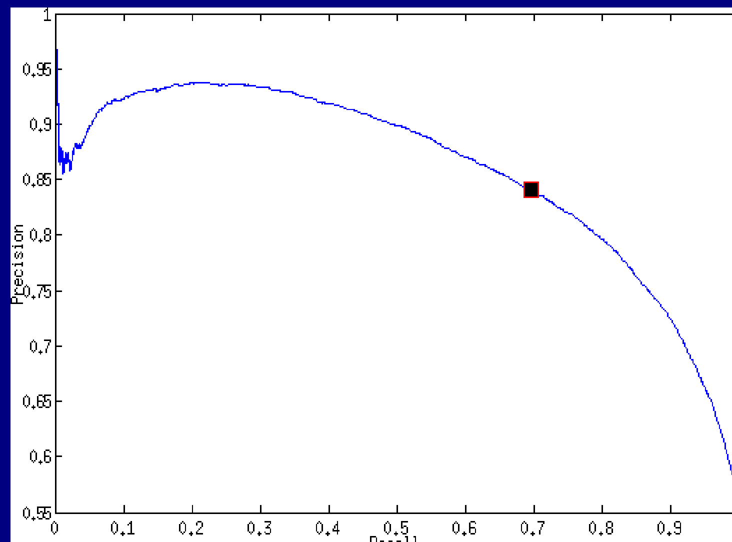


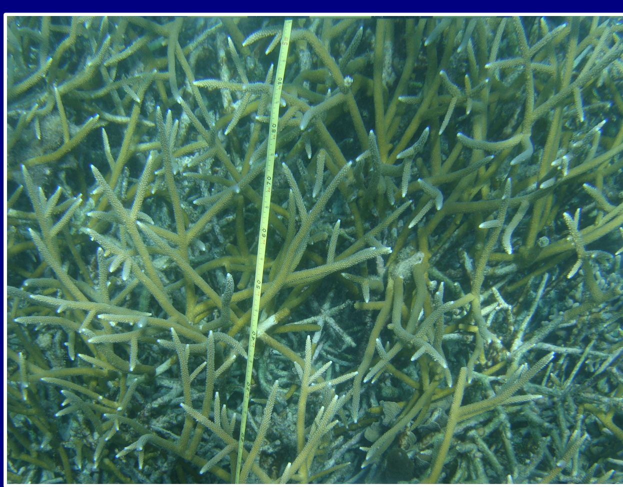


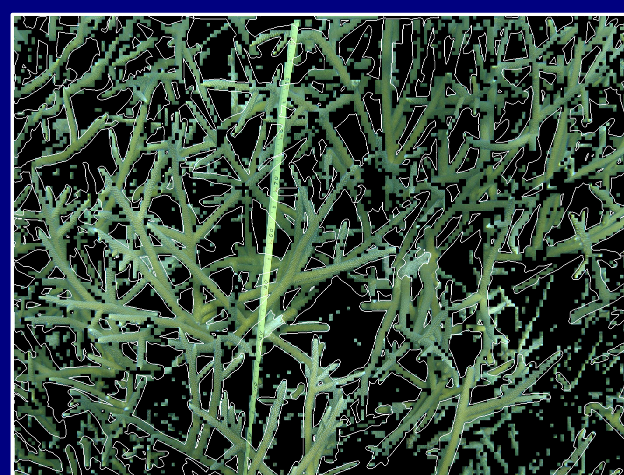


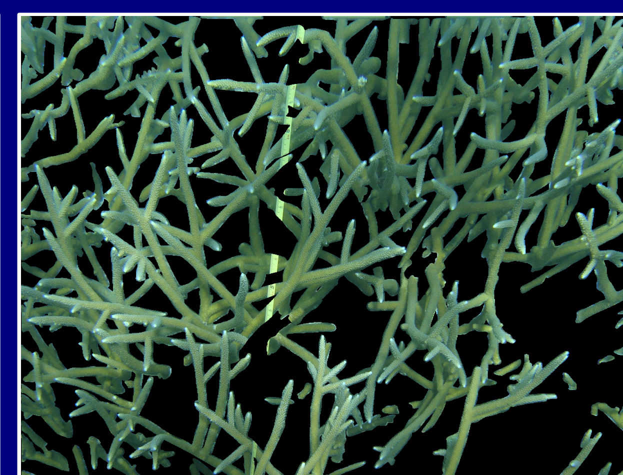


Traversing the PR curve





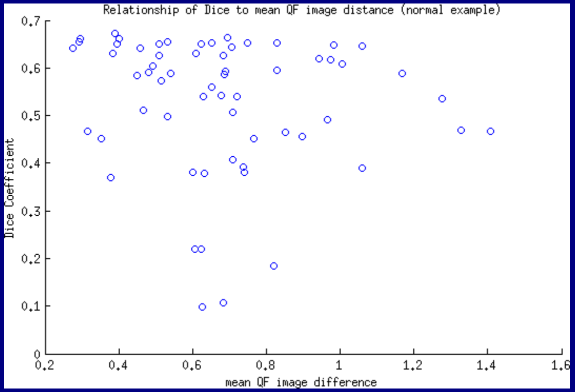




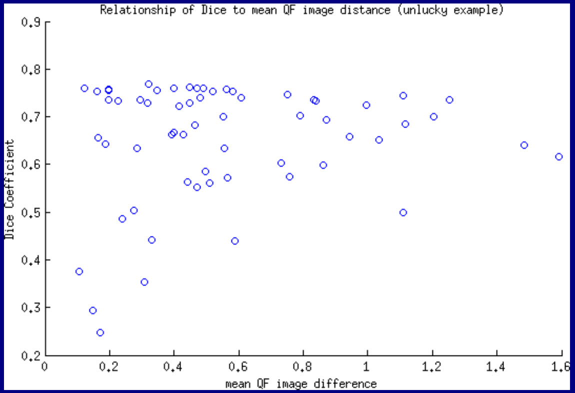
Future: Training Image Choice

- Average QF distance is poor predictor

Normal: closest image provides good training

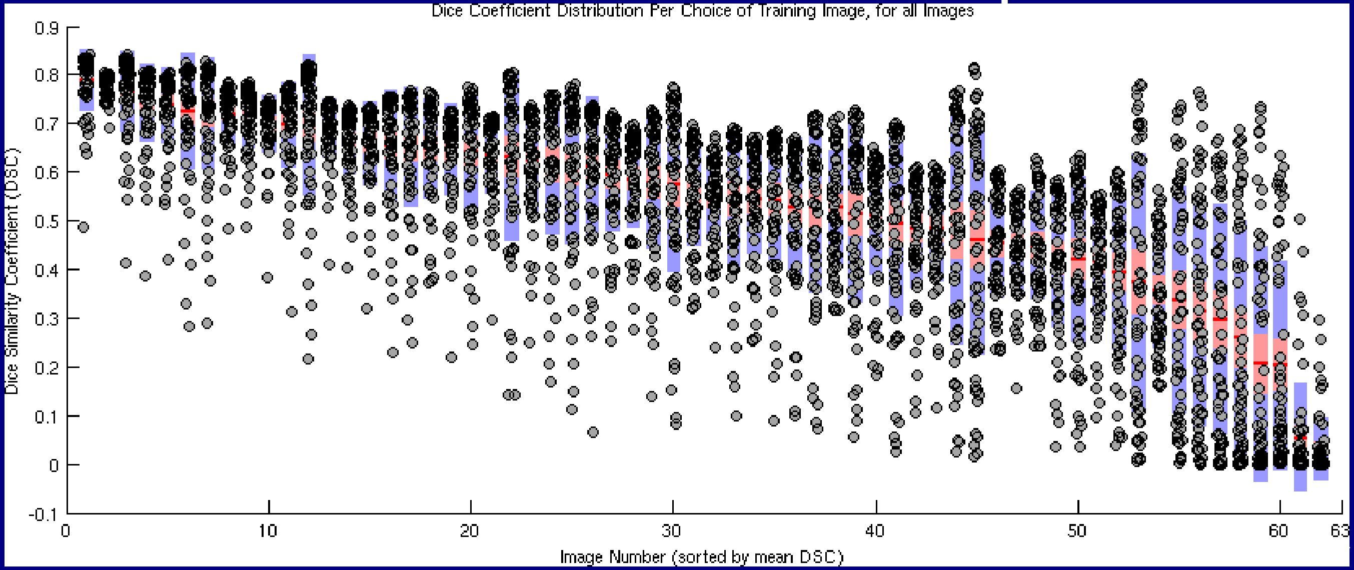


Unlucky: closest image provides poor training



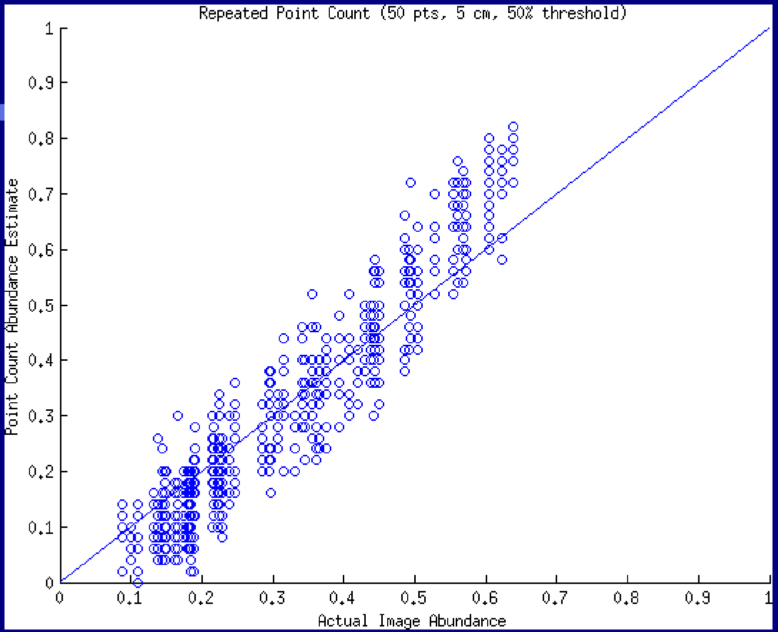
- Image choice matters less than anticipated

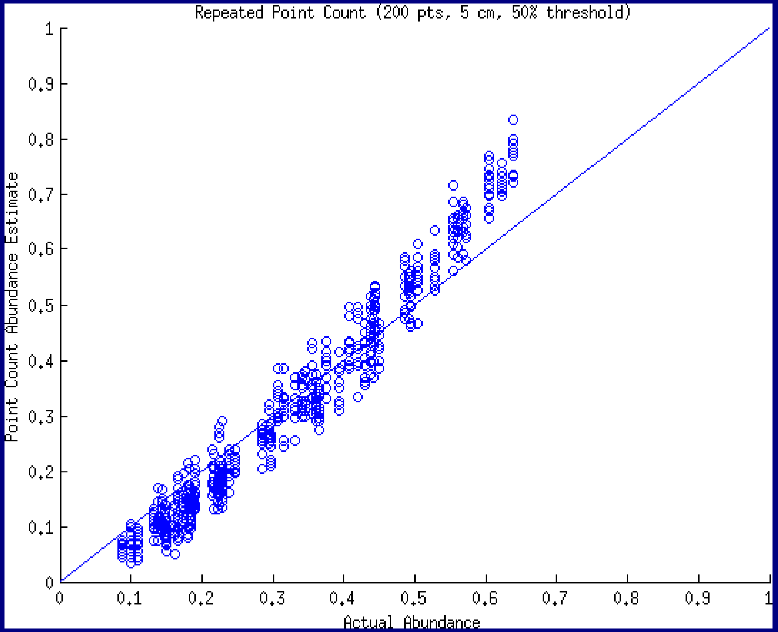
Distribution of DSC over choice of training image, for all images



Point Counting

- Point Counting is biased:
  - Number (of points)
  - Scale of decision
  - Benthic density
  - [Pante et al., 2012]
- Experiment:
  - Manual segmentations as truth
  - Simulate abundance estimation under various point counting parameters





Example positive, negative, 5cm scale

Miscellanea

- Better color normalization within/across images
- Different color spaces
- Boosting, different learners
- Explore feature spaces, inform the above
- Generalizability – separate training/val/test sets

- Erratum: white balance
- Thanks
  - Acquisition/segmentation, coauthors, William Sullivan
  - RE Lee and Lenfest institutional funds

More to do

- -current, future directions: graph cuts, better color alignment across
- regions or images, or a more local match. human interactive final
- product to save time.
- -point counting experiment, computer results showing bias (ref Pante
- article). More forthcoming.
- -erratum: white balance mention in paper.
- -different color spaces experiment. This is closely tied to the color or contrast normalization across an image as well. Often the corners have different lighting conditions (off-angle diffuse), making them darker (especially the images are already quadrat-normalized, then they were already taken off-angle). Should look into color rep's that potentially account for that, or even some model of matte surfaces along with camera angle info discernable from the quadrat selection to normalize color. Maybe that's what NCC (normalized chromaticity coords) accomplishes. Or accounting for shadow.
- -precision/recall curves, oooh with points on the curve corresponding to
- segmentations on those contour images, like the last figure. I would be
- cool to see it grow, hopefully in the right directions.
- -test generalizability of method with separate training and test set,
- maybe, rather than leave one out.
- Adaboost with random forest learner