

Boosted Image Classification: An Empirical Study

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Never the Twain Shall Meet?

Machine Learning

➡ *Improved performance through boosting & other large-margin techniques.*

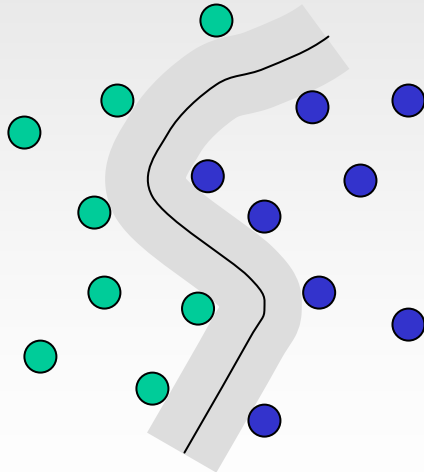
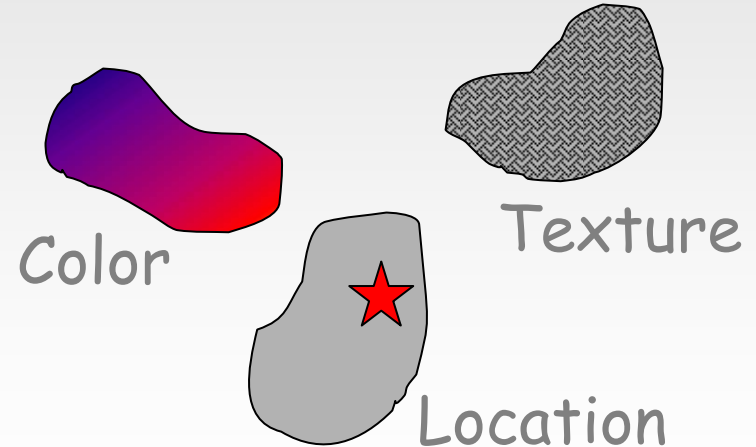


Image Comparison

➡ *Improved performance through better, more comprehensive image representations.*



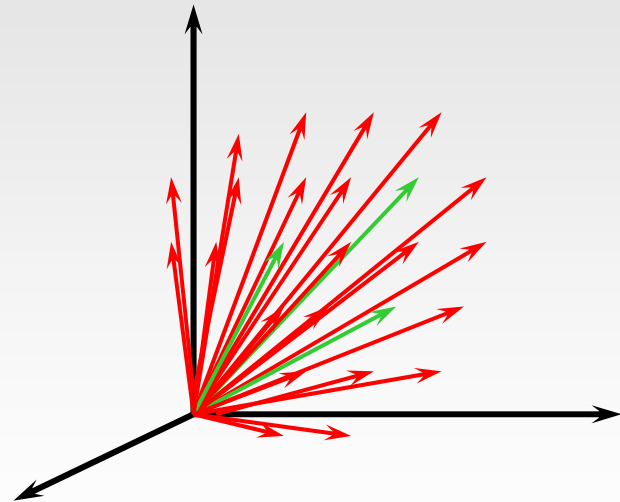
Previous Work

- Tieu and Viola (2000)
 - A good start, but limited
 - Looks at just one candidate image representation
 - Simple, feature-based boosting (i.e., decision stumps)
- Need for more comprehensive investigation

Boosting + **Image Reps** = ?

Image Classification is Hard

- Classes are diffuse.
- Features correlate weakly with class.
- High dimension (10K+)

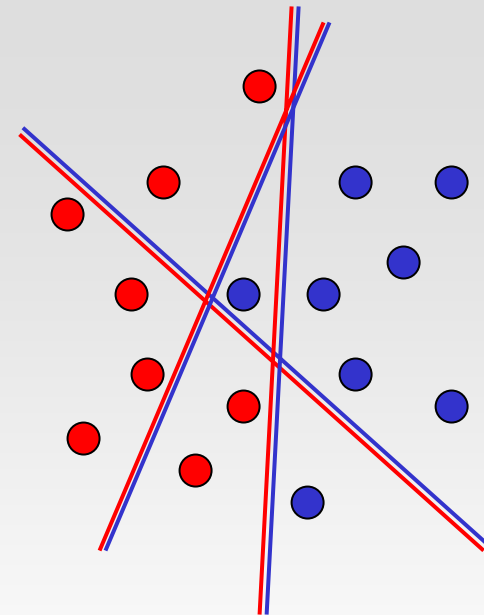


Two Goals of This Work

- Try different ways to apply boosting (i.e., different base classifiers)
- Test boosting with different image representations

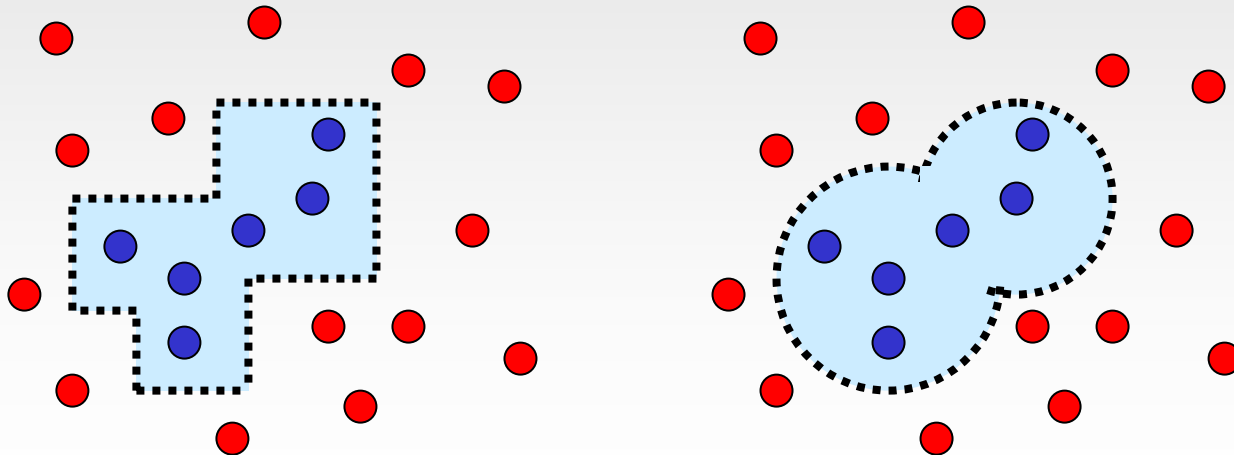
Review of Boosting

- Base classifier must score **>50%** on arbitrarily weighted training set.
- Train base classifier using multiple weightings of training data.
- Combined predictions better than single classifier alone.



Options for a Base Classifier

- Many standard classifiers are "feature-based".
(Decision boundaries orthogonal to feature axes.)
- "Vector-based" classifier may suit images better.
(Decision boundaries are neighborhood around a vector.)

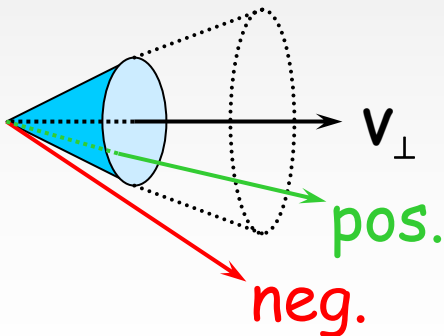
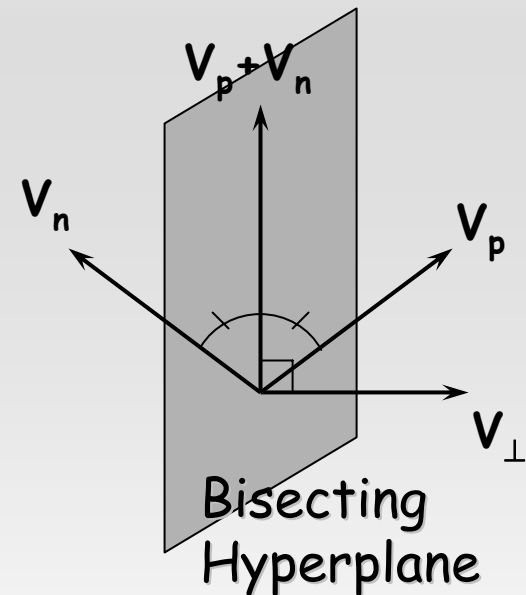


Vector-Based Classifier

$V_p = \sum$ positive instances

$V_n = \sum$ negative instances

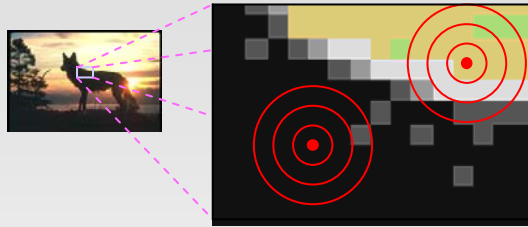
$$V_{\perp} = V_p - \frac{V_n \cdot (V_p + V_n)}{\|V_p + V_n\|^2} (V_p + V_n)$$



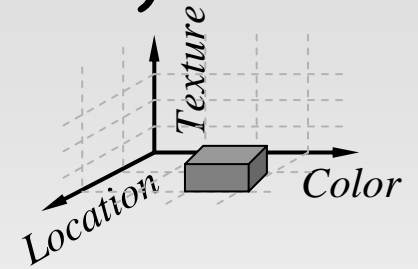
← Instances within some angular radius of V_{\perp} are classified as positive.

Image Representations

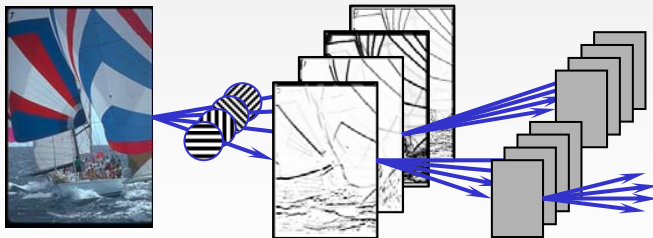
- Correlogram (Huang et. al.)



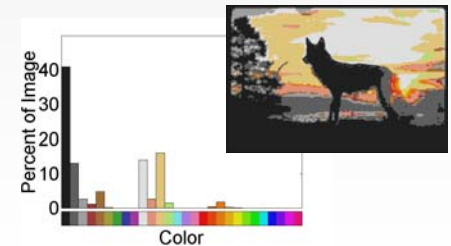
- Stairs (Howe & Huttenlocher)



- Tieu-Viola



- Histogram (Swain & Ballard)



Evaluation Mechanism

- 20K images (Corel)
- 5 categories
- 5x2 cross validation
- Unboosted control:
k-Nearest Neighbor (kNN)

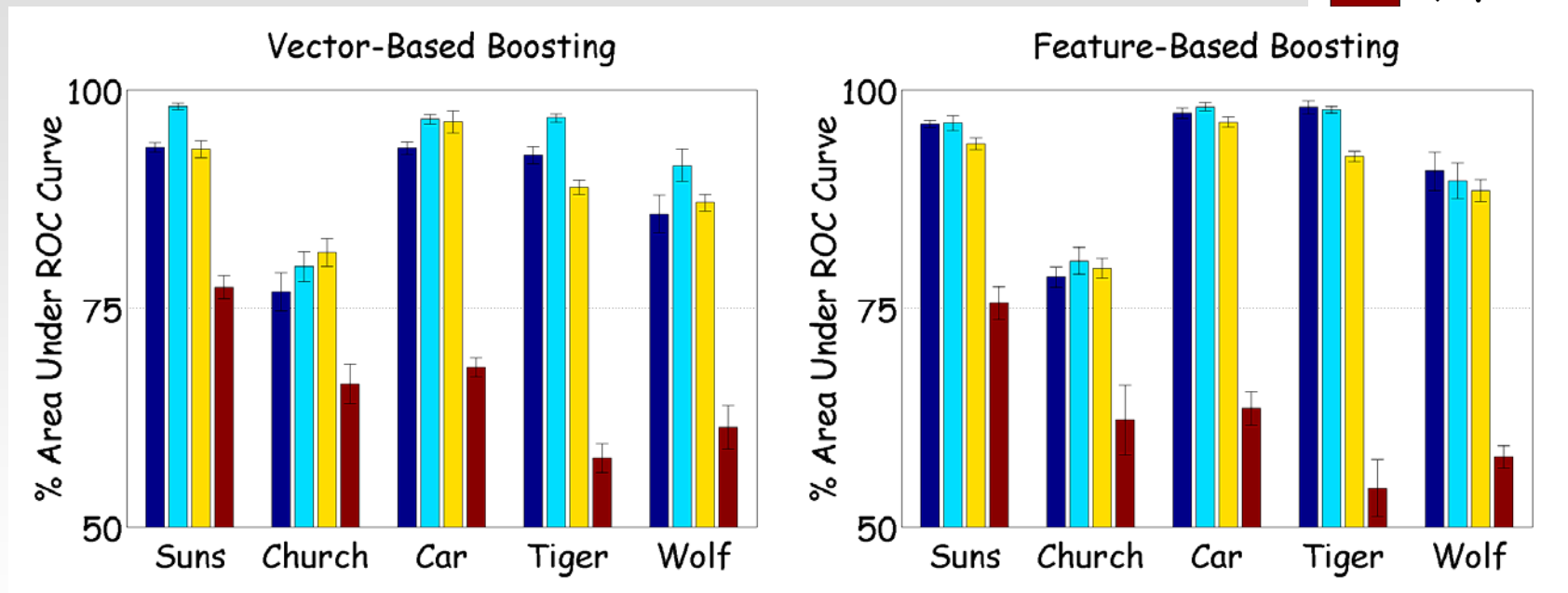
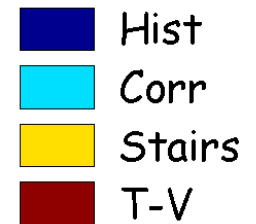


⇒ ROC curves

Comparison based on area under curve.

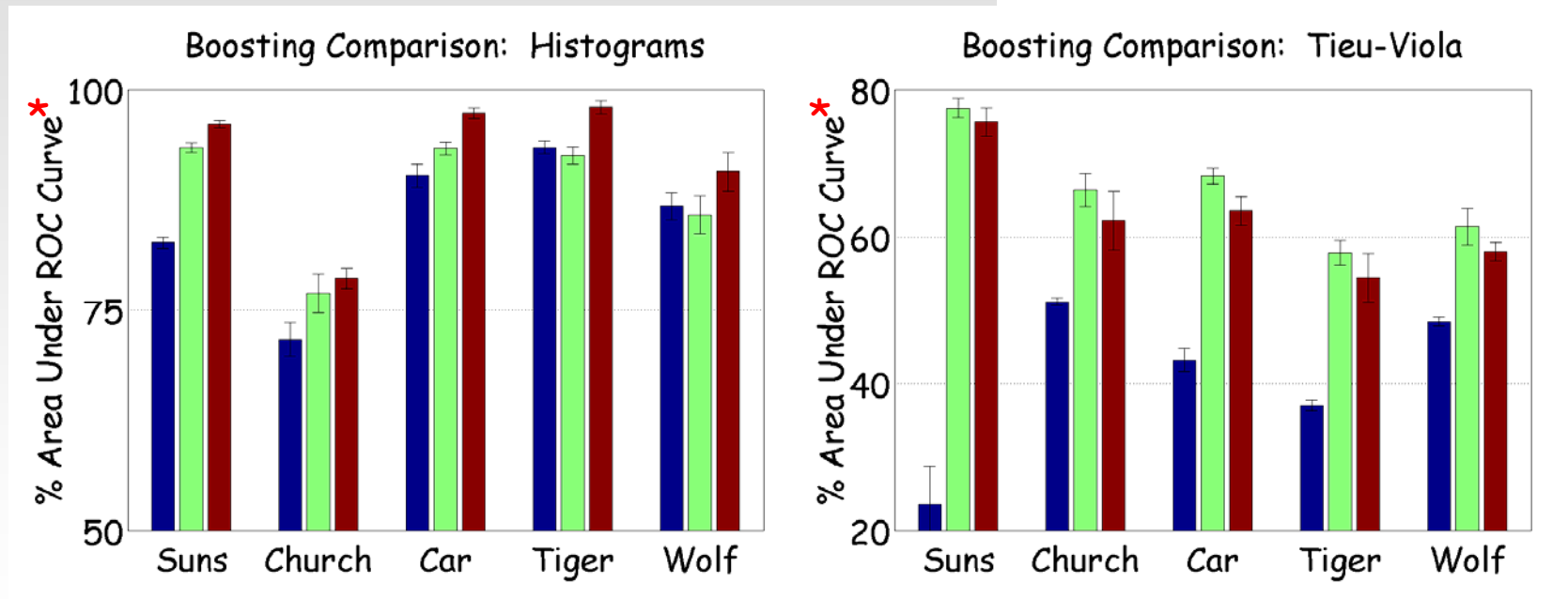
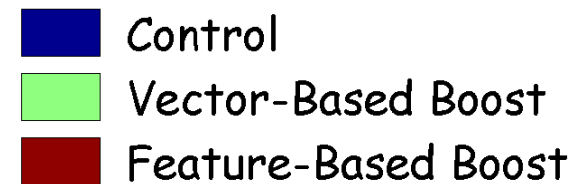
Comparison: Image Reps

- Correlograms do best, T-V worst.



Comparison: Base Classifier

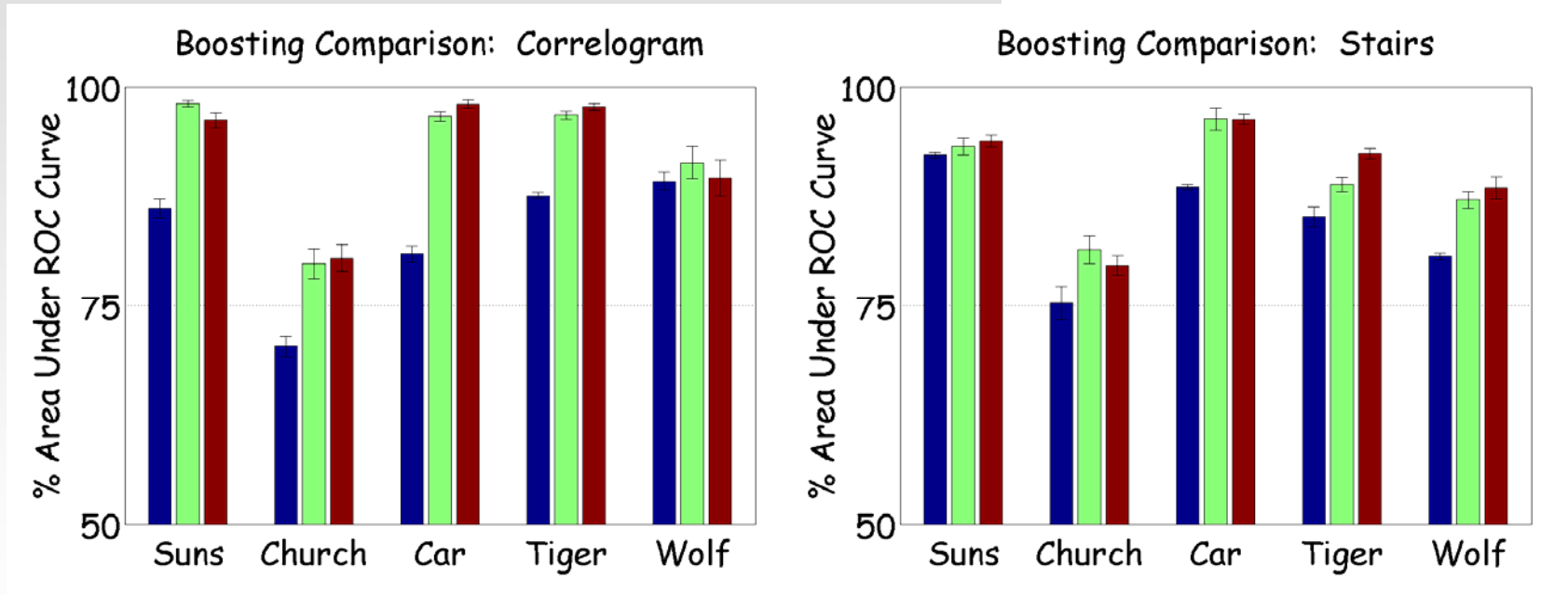
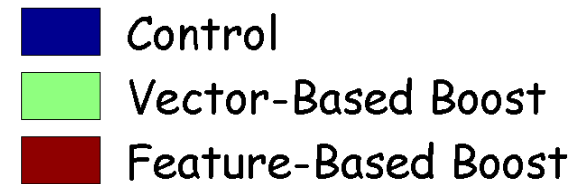
- Best method varies with size of feature space.



* Note differing y axes

More on Base Classifier

- Mid-sized feature spaces show fewer trends.



Conclusion

- Boosting works with a range of image representations. (No surprise!)
- Boosted correlogram is most successful representation.
- Best base classifier varies with size/complexity of feature space.