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.

- Color
- Texture
- Location
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
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

\[ V_p = \sum \text{positive instances} \]
\[ V_n = \sum \text{negative instances} \]
\[ V_\perp = V_p - \frac{V_n \cdot (V_p + V_n)}{\|V_p + V_n\|} \]

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)

$\Rightarrow$ 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.

![Boosting Comparison: Correlogram and Stairs](image-url)
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.