Convergence of Iterated Classification

Chang An and Henry S. Baird

Iterated Classification runs a sequence of classifiers. The same ground-truth is passed to every training phase. Classification results are passed from one classifier to its successor for training and classification. Each classifier is, in general, different from the others.

Strengths of Iterated Classification

- Reduces per-pixel error rates significantly
- Enforces local uniformity ("purity") of regions
- Tends to converge region boundaries to the ground-truth (they don’t drift)
- Avoids arbitrary restrictions: e.g. zones need not be rectangles
- Requires no manual intervention

Novelty

- Made possible by pixel-accurate classification
- Not the same as Cascading Classifiers
- Not Mathematical Morphology
- Not Markov Random Fields

Proof: Iterated Classifiers Converge to GT

- We have often observed convergence on real data.
- Proof for a special case: two-class problem, straight-line boundary (details of proof in paper).
- Using one feature that has also worked well on real data.

Future Work

- “Bootstrap” ground-truth: surprisingly, these classifiers often perform better than loose GT! Maybe we can use classification results as tight GT.
- Investigate under what conditions iterated classifiers will converge to GT in real problems
- Apply iterated classifiers to image processing problems

Task: Pixel-Accurate Segmentation of Document Images

- Original image
- Output of 1st stage
- Color Codes for Content:
  - Blue: Machine Print
  - White: Blank
  - Aqua: Photograph
  - Purple: Handwriting

Result for loose ground-truth

Result for tight ground-truth

Use Classification to Extract Content Layers

Photograph (PH) + Machine Print (MP) + Handwriting (HW)

Experiments: 24% Drop in Error

- Total per-pixel error rate as a function of the stages of classification
- Error rate decreases from 0.214 to 0.173 to 0.114 to 0.164

Another Example of a Complex Layout

- In each stage, a classifier is guided by the GT to correct the errors made by its predecessor
- Note that whether GT is loose or tight, iterated classifiers reduce per-pixel errors and preserve boundaries
- Tight GT allows iterated classifiers to converge more rapidly

Note that the small red circles containing numbers are preserved.