Bootstrapping Image Classification with Sample Evaluation
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ABSTRACT
In this work, we look at the problem of multi-class image classification in a semi-supervised learning framework. Given a small set of labeled images, and a much larger set of unlabeled images, we propose a semi-supervised learning method based on bootstrapping that uses independent and discriminating evaluators to overcome semantic drift. Results show the usefulness of an evaluator in learning difficult examples.

INTRODUCTION
Semi-Supervised Learning

Bootstrapping
1. Learn initial hypothesis from labeled seed examples
2. Classify unlabeled images using current hypothesis
3. Re-train hypothesis using self-labeled images
4. Repeat from step 2

Semantic Drift Elimination
Popular Techniques
Coupled Learning
Mutual Exclusion
Co-Training

Our Approach
Independent Evaluation
Pairwise Discrimination
Hard Negative Promotion

METHOD OVERVIEW
Initial Training
Labeled seed images
Train main classifier
Train evaluator

Bootstrapping with Sample Evaluation
Pool of unlabeled images $\mathcal{U}$
Batch of unlabeled images $\mathcal{U} 
\\subseteq \mathcal{U}$
Label the batch $y = h(u)$
Evaluate labeled images $(u, y) \in E(u, y)$
Retrain classifier $\tilde{h} = \text{train}(u, y)$

Sample Evaluations
To suppress semantic drift, the data to be promoted is subject to the following evaluations

1. Hard negative promotion
Unlabeled images that are classified with low confidence only are promoted.

2. Independent evaluation
Train an independent classifier on a different view (set of features) of the data. Unlabeled instances that the main and independent classifiers agree upon are alone promoted.

3. Enforcing discriminative constraints
One-versus-one SVM classifiers are trained to discriminate between pairs of confusable classes. These pairs of classes are determined from the confusion matrix computed on a validation set.

RESULTS

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<thead>
<tr>
<th>Difficult examples to classify</th>
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<tbody>
<tr>
<td>kitchen</td>
</tr>
<tr>
<td>living room</td>
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<tr>
<td>kitchen</td>
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<tr>
<td>living room</td>
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<td>living room</td>
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</tbody>
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SUMMARY

<table>
<thead>
<tr>
<th>Eliminate Pairwise Confusion</th>
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<tbody>
<tr>
<td>Above Baseline</td>
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<tr>
<td>Hard Negative Promotion</td>
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<tr>
<td>Independent evaluator</td>
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<tr>
<td>Discriminating evaluator</td>
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<td>Independent + Discriminative</td>
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