Weighted One-Against-All (= A simple universal technique for improving one-against-all)

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One-Against-All

One_Against_All(S,LEARN)

1. For all labels $l \in \{1, ..., n\}$
   (a) let $c_l = \text{LEARN}(\{(x, I(y = l)) : (x, y) \in S\})$
2. Return $(c_1, ..., c_l)$

Test$(x, c_1, ..., c_l)$

Uniform from $\{l : c_l(x) = 1\}$ or Uniform random otherwise

One-Against-All efficiency

D = measure over features X cross labels $\{1, ..., n\}$

Theorem: For all D, for all learning algorithms LEARN, if the binary classifiers have average error rate ϵ then the $n-$class classifier has error rate at most $(n-1)\epsilon$

Weighted One-Against-All

Weighted_One_Against_All(S,LEARN)

1. Let $w_0 = \frac{n}{2}$ and $w_1 = n - 1$

2. For all labels $l \in \{1, ..., n\}$

   (a) $c_l = \text{Costing}(\text{LEARN}, \{(x, I(y = l), w_{I(y=l)}) : (x, y) \in S\})$

3. Return $(c_1, ..., c_l)$

Test: the same

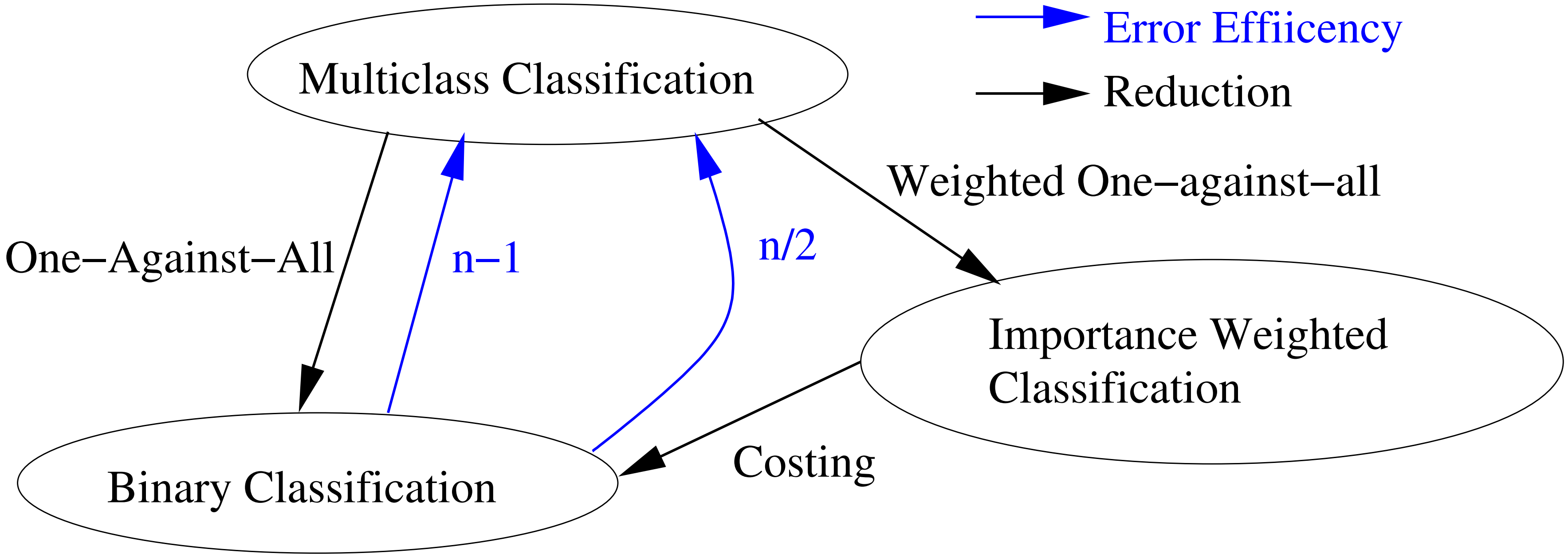
Weighted One-Against-All efficiency

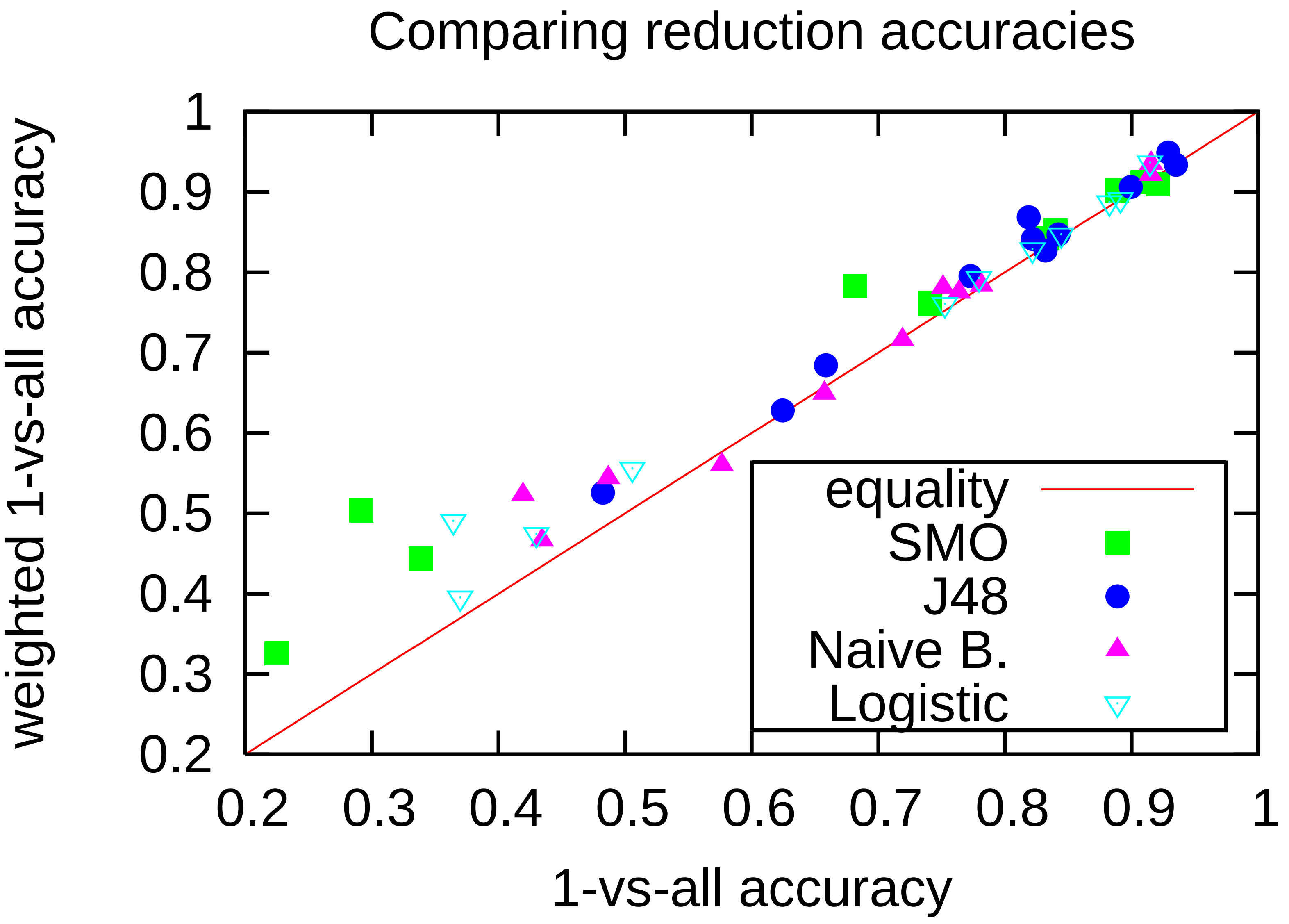
Theorem: For all D, for all learning algorithms LEARN, If the binary classifiers have average error rate ϵ then the $n-$class classifier has error rate at most $\frac{n}{2}\epsilon$

Generalization: The analysis applies more generally to "subset classification" or "multilabel classification" where k of n labels are "right" and $n-k$ are "wrong".

Other Approaches: More work, unclear performance comparison

1. ECOC (Dietterich & Bakiri 1995) and variants
   (a) margin-ECOC (Allwein, Schapire, Singer, JMLR 2000). Theoretically interesting
   (b) SECOC (Beygelzimer & Langford, COLT 1995). Theoretically appealing
2. Probabilistic one-against-all. Reduces to stronger primitive. Empirically used, comparison unclear.


Error Effiicency
Reduction
Multiclass Classification
Weighted One−against−all
One−Against−All
n−1
n/2
Importance Weighted Classification
Costing
Binary Classification


Comparing reduction accuracies
weighted 1-vs-all accuracy
1-vs-all accuracy
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
equality
SMO
J48
Naive B.
Logistic