Active Learning with Adaptive Heterogeneous Ensembles

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Introduction

The combination of ensemble methods and active learning is promising.

Given a data set, how to choose an appropriate base classifier, or a combination of base classifiers is challenging.

The focus of our work is developing algorithms that can automatically find ensembles with appropriate combination of classifier types.

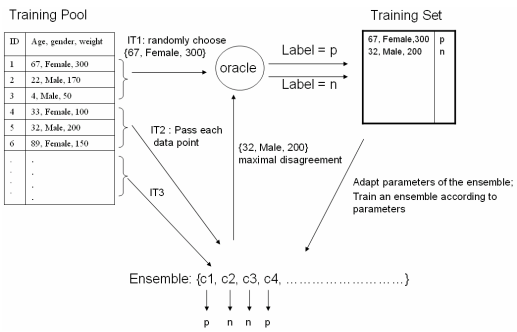

Figure 1. Algorithm Framework

Adaptive Informative Sampling (AIS)

Diversity of ensemble members obtained through stochastic optimization.

Adapt the ratio of involving classifier types towards better performance.

In this work, Artificial Neural Networks (ANN) and Decision Trees (DT) serve as the classifier types.

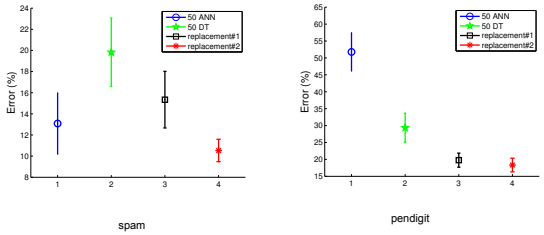

Figure 2. Results of Adaptive Informative Sampling

Adaptive Heterogeneous Ensembles (AHE)

The random subspace method (RSM) is used to obtain multiple instances of different classifier types.

C4.5 and Naïve Bayes classifiers are employed as the classifier types. Experiments were conducted on five UCI data sets.

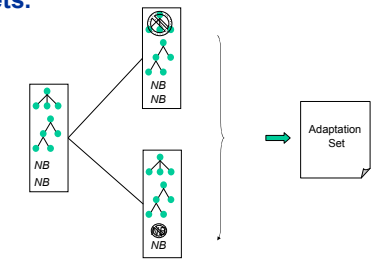

Figure 3. Adaptation method of AHE.

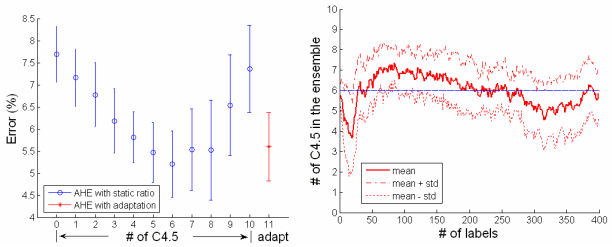

Figure 4. Results of AHE on "mfeat-pixel" data set.

	C4.5 with uncertainty	Naïve bayes uncertainty	AHE random sampling	Bagging random	Boosting random	RSM random	AHE
mfeat-pixel	14.83 ± 2.35 ***	11.83 ± 0.66 ***	8.28 ± 1.41 ***	10.89 ± 1.35 ***	8.36 ± 1.13 ***	10.17 ± 1.74 ***	**5.6 ± 0.78**
page	3.99 ± 0.4 ***	23.64 ± 4.9 ***	3.67 ± 0.54 ***	3.54 ± 0.45 ***	3.51 ± 0.53 ***	3.64 ± 0.5 ***	**2.73 ± 0.36**
satImg	23.89 ± 2.86 ***	20.11 ± 0.47 ***	17.33 ± 0.92 ***	18.6 ± 1.7 ***	17.8 ± 1.25 ***	17.32 ± 1.31 ***	**14.84 ± 0.98**
spam	12.29 ± 1.74 ***	20.75 ± 0.35 ***	7.21 ± 0.99 ***	8.31 ± 0.56 ***	6.83 ± 0.77 **	6.9 ± 0.87 **	**6.21 ± 0.81**
waveform	31.16 ± 3.21 ***	20.81 ± 1 ***	20.96 ± 1.54 ***	23.67 ± 2.19 ***	22.49 ± 1.47 ***	22.82 ± 2.07 ***	**19.48 ± 1.49**

Table 1. Results of AHE on five UCI data sets.

In Progress

Variably-sized Adaptive Heterogeneous Ensembles (VAHE) is an extension of AHE:

- kNN added as the third classifier type
- both ratio of classifier types and ensemble sizes are adapted

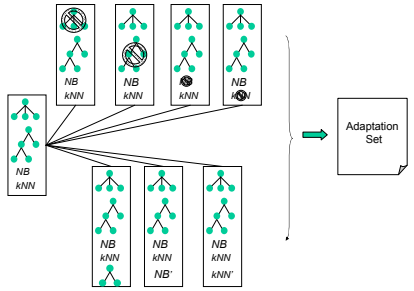

Figure 5. Adaptation method of VAHE.

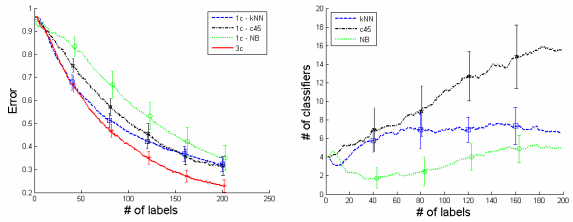

Figure 6. Results of VAHE on "isolet" data set.

	C45 ensemble	NB ensemble	kNN ensemble	Bagging random	Boosting random	RSM random
20%	13-5-0	18-0-0	13-4-1	16-1-1	15-3-0	17-1-0
40%	14-3-1	16-2-0	13-5-0	17-1-0	16-2-0	18-0-0
60%	11-5-2	15-3-0	12-6-0	17-0-1	16-2-0	16-2-0
80%	12-5-1	16-2-0	13-4-1	17-0-1	17-1-0	17-1-0
100%	12-6-0	17-1-0	13-4-1	17-0-1	18-0-0	17-0-1
Adaptation incorporated	9-4-5	18-0-0	11-5-2	15-2-1	13-4-1	14-2-2

Table 2. Win-tie-loss of VAHE compared with other methods on 18 UCI data sets.

Conclusions and Future Work

Adaptive heterogeneous ensembles work consistently better than homogeneous ensembles and state-of-the-art ensemble methods.

Future work:

- better adaptation method
- in-depth analysis of the algorithm

Acknowledgments

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