

A Survey on Properties of Adaptive Boosting with Different Classifiers

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Abstract: Adaboost or Adaptive boosting is a recently using boosting technique in machine learning. Generally boosting is used to improve the performance of various learning algorithms. It is mainly used in conjunction with different classifiers. This paper takes a survey based on the properties shown by adaboost with different base classifiers like, support vector machine, naive bayes, decision trees and decision stump. Boosting of these classifiers with adaboost shows difference in properties such as accuracy, error rate, performance etc. Adaptive boosting is widely used in various fields of data mining and image recognition. Now a days it is very helpful in the prediction and diagnosis of particular disease patterns with maximum degree of accuracy by converting a weak learner into a strong learner.

Keywords: Adaboost, AdaBoostSVM, RBFSVM, Naive Bayes, Decision trees, Decision stump

1. Introduction

Boosting is a technique in ensemble learning that converts weak learners into strong learners. Adaboost is a type of boosting, introduced in 1995 by Freund and Schapire. It runs in polynomial time [1]. And requirement of more parameters is insignificant. Its name indicates its adaptive nature. It works by selecting a base algorithm. The output of the selected algorithm is taken as the final output of the boosted classifier that must be combined a weighted sum.

Adaboost works in the training phase. First step is assigning equal weights to the given training examples. Then select the base algorithm and apply it on the data. If prediction is incorrect using the first learner, then it gives higher weight to observation which has been predicted incorrectly and also decreases the weight of correctly predicted samples. Continue the iteration n times and update weights until the maximum accuracy obtained.

We can use adaboost with different base classifiers and each can show variations in properties. A combination of Adaboost with an appropriate base classifier lead to successful prediction in different fields such as medical data mining, educational data mining, image recognition etc. Different base classifiers used here to explain with Adaboost are SVM, Naive bayes, Decision trees and Decision stump.

2. Working of Adaboost with Base Classifiers

2.1 Support Vector Machine

Support vector machines include in supervised machine learning category. It usually separates a hyperplane in a high dimensional space and is a discriminative classifier. Hyperplane gives the lowest distance to the training examples. It can be used for data analysis of classification and regression. The main goal of the margin is to maximize the number of support vectors and thereby

increasing the prediction accuracy [2]. In addition, SVM uses kernels for non linear classification. Figure 1 shows a separated optimal hyperplane that maximizes the margin of training examples.

Adaboost with SVM as weak learner is called AdaBoostSVM. SVM uses suitable kernel functions to compute weights, threshold values, location of centers etc. In most cases, RBF is used as kernel function. The performance of classification depends on its parameters. The Gaussian width σ and the regularization parameter C are the parameters used for RBFSVM. Although RBFSVM cannot learn well when a very low value of C is used, its performance largely depends on the σ value if a roughly suitable C is given [3].

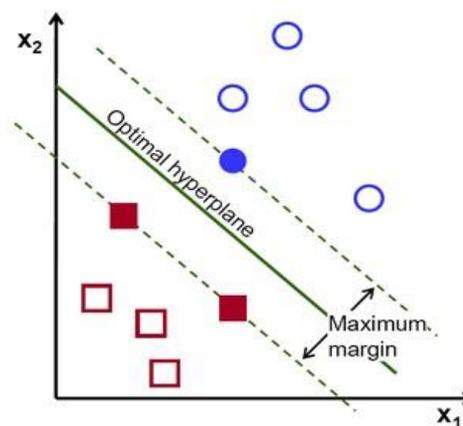


Figure 1: Separated Optimal Hyperplane

But increasing or decreasing the value of σ creates complex classification problem. So the AdaBoostSVM uses a set of moderately accurate RBFSVM that adjusting the σ values adaptively rather than using a fixed σ value. This gives better classification performance and also finds solution for unbalanced classification problems. Figure 2 shows the improvement of AdaBoostSVM over SVM on unbalanced

problems when using UCI repository 'splice' dataset as UCI benchmark.

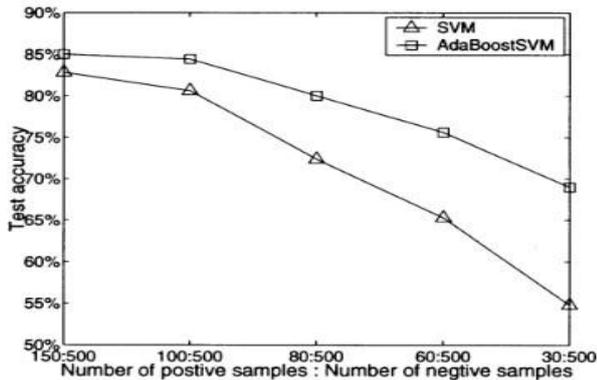


Figure 2: Compare SVM and AdaBoostSVM on unbalanced problem

The performance of AdaBoostSVM over SVM increases with the decreasing ratio of number of positive samples to the negative samples. The AdaBoostSVM has advantages of easier model selection and better generalization performance. It also provides a possible way to handle the over-fitting problem in Adaboost. In the case of unbalanced problems, AdaBoostSVM shows better performance when comparing with support vector machine.

2.2 Naive Bayes

The working of Naive Bayes classifiers are based on Bayes Theorem. They are very efficient and probabilistic classifiers and includes in supervised machine learning category. The algorithm is assigned to a class label which is learned by conditional probability and from training data and all attributes is independent with respect to the class label. Bayesian rule is applied to compute the probability of class label and the highest posterior probability class is calculated [5].

$$W_t$$

The boosting of naive bayes with Adaboost depends on the stability of the classifier. Studies show that boosting does not work well for naive Bayesian classification because of the stability of naive bayes with strong bias [6]. However by reducing bias and increasing its variance makes the classifier unstable and helps in successful boosting. Introducing tree structures into naive bayes can reduce bias and increases variance by using maximum depth of trees.

2.3 Decision trees and Decision stump

Decision trees are graph like structures with decisions and their possible effects and contain root node, internal nodes and leaf nodes. The root node and terminal node includes different test conditions to separate different attributes [7].

Applying adaboost algorithm to decision trees are very effective than other classifiers with adaboost because of its non linearity. And also they are possibly fast to train.

Decision stump is a category of decision tree consisting only one level. It uses the most prominent attribute for prediction [2]. Figure 3 shows working of decision stump.

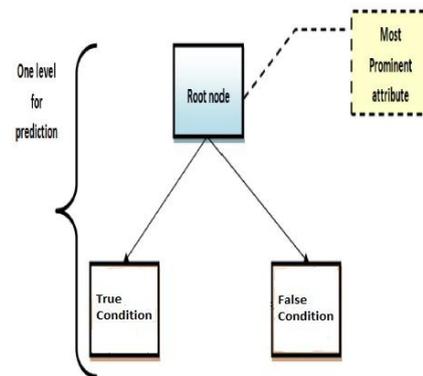


Figure 3: Working of Decision stump.

Adaboost with decision stump as weak learner is widely used now a days because of its great success in boosting. Boosting is started by applying equal weights to all points and find decision stump with lowest weighted training error according to the initial weights. Finding best decision stump or best attribute is important in boosting. So for selecting best attribute, consider splitting on each feature and pick the lowest weighted error. The coefficient for the particular classifier is computed by the formula

$$W_t = \frac{1}{2} \ln \left(\frac{1 - \text{weighted error}(f_t)}{\text{weighted error}(f_t)} \right) \quad (1)$$

Where f_t is selected decision stump or attribute. Then recomputed and normalize the weights and final model is predicted by the formula

$$y = \text{sign}(\sum_{t=1}^T W_t f_t(x))$$

Where is the coefficient.

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Boosting decision stumps improves predictive performance as well as speed. Different studies show that Adaboost- decision stump classifier provides highest accuracy and low value of error rate [2]. Many face detection algorithms like Viola-Jones and many disease predictions employ Adaboost- decision stump combination.

3. Discussion

Most fields in data mining and image recognition tried to utilize the benefits with boosting and many of them achieved successful results. Introduction of Adaboost is a milestone in ensemble learning because of its adaptive nature.

Boosting of different base classifiers with Adaboost shows variations in properties. Boosting of support vector machine

shows better generalization performance and ways to handle the overfitting problem by selecting proper parameters. It also shows that a noticeable increase in accuracy by the use of moderately accurate SVM learners. In the case of Naive bayes , boosting does not work well because of its stability. However introduction of tree structures into naive Bayesian classifier makes it unstable and helps in successful boosting. Non linear structure of decision trees is very effective in boosting. Also it solves overfitting problem as SVM do. Performance and speed are more than SVM and Naive Bayes. The one level decision tree, Decision stump shows high accuracy and low error rate because of the use of best single attribute with adaptive boosting.

4. Conclusion

This survey concludes that SVM, Naive Bayes, Decision trees and Decision stumps shows variations in their properties with Adaboost. Comparing these classifiers, SVM, decision trees and decision stump improves performance with adaboost while Naive Bayes does not show any improvement. Decision stump provides higher accuracy and low error value in prediction than the other classifiers.

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