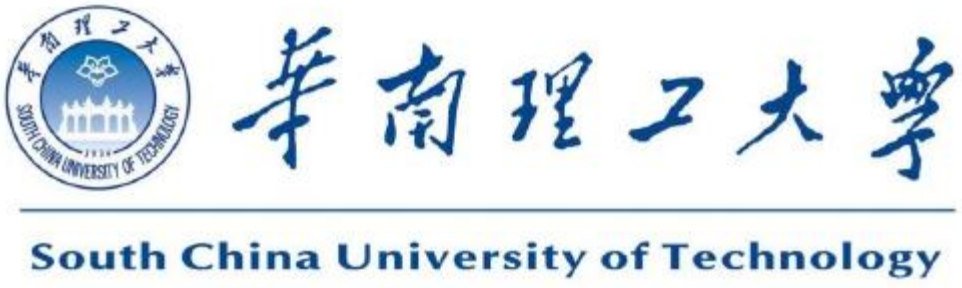

The Experiment Report of Machine Learning

SCHOOL: SCHOOL OF SOFTWARE ENGINEERING

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Author:
Xiaoxuan Peng

Supervisor:
Mingkui Tan

Student ID：
201730683321

Grade:
Undergraduate

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Face Detection Based on AdaBoost Algorithm

Abstract—This experiment intends to use Adaboost to solve the face detection problem and combine the theory with the actual project.

I. INTRODUCTION

Adaboost is a kind of ensemble methods to combine some different weak classifiers to form a strong classifier. In this experiment, I use decision trees with a small height as the weak classifiers to form a strong classifier in face-detection problem.

II. METHODS AND THEORY

A. Sample weight updating formula

$$w_{m+1}(i) = \frac{w_m(i)}{z_m} e^{-\alpha_m y_i h_m(\mathbf{x}_i)}$$

$z_m = \sum_{i=1}^{n} w_m(i) e^{-\alpha_m y_i h_m(\mathbf{x}_i)}$ is normalization term, makes $w_m(i)$ become probability distributions.

$$w_{m+1}(i) = \begin{cases} \frac{w_m(i)}{z_m} e^{-\alpha_m} & \text{for right predictive sample} \\ \frac{w_m(i)}{z_m} e^{\alpha_m} & \text{for wrong predictive sample} \end{cases}$$

So in next round, $\frac{w_{wrong}(i)}{w_{right}(i)} = e^{2\alpha_m} = \frac{1-\epsilon_m}{\epsilon_m}$ and ϵ_m<0.5, wrong samples will be more important.

B. Evaluate the performance of the base learner

a) Base learner:

$$h_m(\mathbf{x}): \mathbf{x} \mapsto \{-1,1\}$$

b) Error rate:

$$\epsilon_m = p(h_m(\mathbf{x}) \neq y_i) = \sum_{i=1}^{n} w_m(i) \mathbb{I}(h_m(\mathbf{x}_i) \neq y_i)$$

$\epsilon_m < 0.5$, or the performance of Adaboost is weaker than random classification.

c) Important score of base learner:

$$\alpha_m = \frac{1}{2} \log \frac{1-\epsilon_m}{\epsilon_m}$$

Make the base learner with lower ϵ_m more important.

C. Additive model

Final learner:

$$H(\mathbf{x}) = \text{sign}\left(\sum_{m=1}^{M} \alpha_m h_m(\mathbf{x})\right)$$

Note: $h_m(\mathbf{x}) = \text{sign}(\boldsymbol{w}^T \boldsymbol{x})$ is a nonlinear function, so the Adaboost can deal with nonlinear problem.

Algorithm 2: Adaboost

Input: $D = \{(\mathbf{x}_1, y_1), ..., (\mathbf{x}_n, y_n)\}$, **where** $\mathbf{x}_i \in X, y_i \in \{-1, 1\}$
Initialize: Sample distribution w_m
Base learner: $\mathcal{L}$

$w_1(i) = \frac{1}{n}$
for m=1,2,...,M **do**
  $h_m(x) = \mathcal{L}(D, w_m)$
  $\epsilon_m = \sum_{i=1}^{n} w_m(i) \mathbb{I}(h_m(\mathbf{x}_i) \neq y_i)$
  if $\epsilon_m > 0.5$ **then**
    break
  end
  $\alpha_m = \frac{1}{2} \log \frac{1-\epsilon_m}{\epsilon_m}$
  $w_{m+1}(i) = \frac{w_m(i)}{z_m} e^{-\alpha_m y_i h_m(\mathbf{x}_i)}$, **where** $i = 1, 2, ..., n$ **and**
  $z_m = \sum_{i=1}^{n} w_m(i) e^{-\alpha_m y_i h_m(\mathbf{x}_i)}$
end
Output: $H(\mathbf{x}) = \sum_{m=1}^{M} \alpha_m h_m(\mathbf{x})$

III. EXPERIMENT

A. Dataset

This dataset contains 1000 images. There are 500 RGB images with face included and there are 500 RGB images without face.

B. Implementation

(1) Initialization

The dataset is split into two parts, 70% for training set and 30% for validation set, we don't generate test set here.

Also, I initialize parameter w with a vector filled with 1.

(2) Parameters

Table 1 shown below lists all the parameters.

Table 1-Parameters in Adaboost

Parameters	Values
DecisionTree-criterion	entropy
DecisionTree-max_depth	2
DecisionTree-class_weight	balanced
Number of weak classifiers	15

(3) Results

a) Face classification using Adaboost

Table 2 shown below list the result computed by classification_report() function in sklearn.metrics library.

Table 2-Final result in Adaboost

	precision	recall	F1-score	support
face	0.80	0.89	0.84	149
nonface	0.88	0.77	0.82	151
accuracy			0.83	300
Macro avg	0.84	0.83	0.83	300
Weighted avg	0.84	0.83	0.83	300

b) Face detection using Haar Feature-based Cascade Classifiers

Figure 1 shown below shows the initial image with a face, figure 2 shown below shows the result image after using face detection method.

Figure 1-initial image

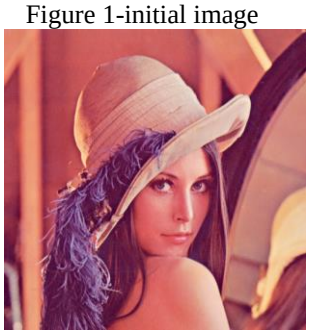

Figure 2-result image

IV. CONCLUSION

(1) OpenCV library in python is a powerful library to process images.
(2) Adaboost is a useful ensemble method to combine some weak classifier(base learner) to form a strong classifier.
(3) As a weak classifier in the experiment, the height of the Decision tree should not be too deep, otherwise only a DecisionTreeClassifier can classify the face well.