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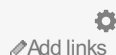
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# Winnow (algorithm)

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(Redirected from **Wnnow algorithm**)

The **winnow algorithm**<sup>[1]</sup> is a technique from **machine learning** for learning a **linear classifier** from labeled examples. It is very similar to the **perceptron algorithm**. However, the perceptron algorithm uses an additive weight-update scheme, while Winnow uses a multiplicative scheme that allows it to perform much better when many dimensions are irrelevant (hence its name). It is a simple algorithm that scales well to high-dimensional data. During training, Winnow is shown a sequence of positive and negative examples. From these it learns a decision **hyperplane** that can then be used to label novel examples as positive or negative. The algorithm can also be used in the **online learning** setting, where the learning and the classification phase are not clearly separated.

## Algorithm <sup>[edit]</sup>

The basic algorithm, Winnow1, is as follows. The instance space is  $X = \{0, 1\}^n$ , that is, each instance is described as a set of **Boolean-valued features**. The algorithm maintains non-negative weights  $w_i$  for  $i \in \{1 \dots n\}$ , which are initially set to 1, one weight for each feature. When the learner is given an example  $(x_1, \dots, x_n)$ , it applies the typical prediction rule for linear classifiers:

- If  $\sum_{i=1}^n w_i x_i > \Theta$ , then predict 1
- **Otherwise** predict 0

Here  $\Theta$  is a real number that is called the *threshold*. Together with the weights, the threshold defines a dividing hyperplane in the instance space. Good bounds are obtained if  $\Theta = n/2$  (see below).

For each example with which it is presented, the learner applies the following update rule:

- If an example is correctly classified, do nothing.
- If an example is predicted to be 1 but the correct result was 0, all of the weights implicated in the mistake are set to 0 (demotion step).
- If an example is predicted to be 0 but the correct result was 1, all of the weights implicated in the mistake are multiplied by  $\alpha$  (promotion step).

Here, "implicated" means weights on features of the instance that have value 1. A typical value for  $\alpha$  is 2.

There are many variations to this basic approach. *Winnow2*<sup>[1]</sup> is similar except that in the demotion step the weights are divided by  $\alpha$  instead of being set to 0. *Balanced Winnow* maintains two sets of weights, and thus two hyperplanes. This can then be generalized for **multi-label classification**.

## Mistake bounds <sup>[edit]</sup>

In certain circumstances, it can be shown that the number of mistakes Winnow makes as it learns has an **upper bound** that is independent of the number of instances with which it is presented. If the Winnow1 algorithm uses  $\alpha > 1$  and  $\Theta \geq 1/\alpha$  on a target function that is a  $k$ -literal monotone disjunction given by  $f(x_1, \dots, x_n) = x_{i_1} \cup \dots \cup x_{i_k}$ , then for any sequence of instances the total number of mistakes is bounded by:  $\alpha k (\log_\alpha \Theta + 1) + \frac{n}{\Theta}$ .<sup>[2]</sup>

## References <sup>[edit]</sup>

- ↑ <sup>*a*</sup> <sup>*b*</sup> Nick Littlestone (1988). "Learning Quickly When Irrelevant Attributes Abound: A New Linear-threshold Algorithm", *Machine Learning* 285–318(2) .
- ↑ Nick Littlestone (1989). "Mistake bounds and logarithmic linear-threshold learning algorithms". Technical report UCSC-CRL-89-11, University of California, Santa Cruz.

**Categories:**  Classification algorithms

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