



## Why

What is the best linear predictor if we choose according to a particular norm.

## Definition

Suppose we have a paired dataset of  $n$  records with inputs in  $\mathbf{R}^d$  and outputs in  $\mathbf{R}$ . A *norm weighted least squares linear predictor* for a norm  $g : \mathbf{R}^n \rightarrow \mathbf{R}$  is a linear transformation  $f : \mathbf{R}^d \rightarrow \mathbf{R}$  (the field is  $\mathbf{R}$ ) which minimizes

$$g(y - Ax).$$

## Weight matrix

Let  $\|\cdot\|_W$  be the weighted norm for some positive semidefinite weight matrix  $W$ . We want to find  $x$  to minimize

$$\|y - AX\|_W.$$

This problem is referred to by many authors as *weighted least squares* or the *weighted least squares problem*.

## Diagonal weight matrix

A special case of norm weighted least squares with a weighted norm is the usual weighted least squares problem (see **Weighted Least Squares Linear Predictors**). Consider weighted least squares with weights  $w \in \mathbf{R}^n$ ,  $w \geq 0$ . Define  $W \in \mathbf{R}^{n \times n}$  so that  $W_{ii} = w_i$  and  $W_{ij} = 0$  when  $i \neq j$ . So, in particular,  $W$  is a diagonal matrix and

$$\|y - Ax\|_W = \sum_{i=1}^n w_i (y_i - x^\top a_i)^2.$$

**Solution**

**Proposition 1.** *There exists a unique weighted least squares linear predictor and its parameters are given by*

$$(A^\top W A)^{-1} A^\top W y.$$

