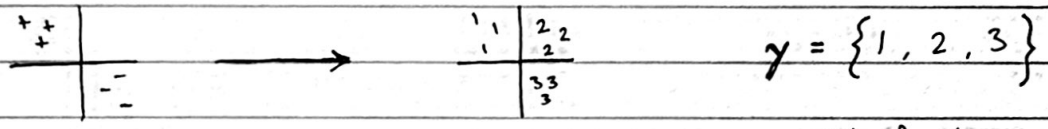
Multiclass Classification

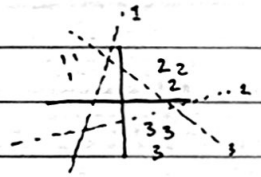


Binary classification → Multiclass

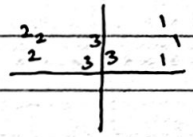
$\mathcal{Y} = \{1, 2, 3\}$

Set of classes (output space)

- One-vs.-all : n binary classifiers



Doesn't always work!



- Two Techniques

1. One weight vector per class (Different weights, DW)
2. Different features (DF) per class

Different Weights: $\underset{y \in \mathcal{Y}}{\text{argmax}} \; \bar{w}_y^T f(\bar{x})$

Fixed set of features, hit this w/ diff. weight vectors, and weight vector that has highest dot product is prediction

Different Features: $\underset{y \in \mathcal{Y}}{\text{argmax}} \; \bar{w}^T f(\bar{x}, y)$

↑ hypothesized y

- Topic Classification Example

$\bar{x}$ = Too many drug trials, too few patients

$\mathcal{Y} = \{\text{Health}, \text{Sports}, \text{Science}\}$

$f(\bar{x})$ = Bag-of-unigrams [drug, patients, baseball]

$f(\bar{x}) = [1, 1, 0]$

DW: $\bar{w}_{\text{health}} = [2, 5.6, -3]$ $\quad \bar{w}_{\text{sports}} = [1.2, -3.1, 5.7]$

$\bar{w}_{\text{health}} f(\bar{x}) \Rightarrow 7.6$ $\quad \bar{w}_{\text{sports}} f(\bar{x}) \Rightarrow -1.9$

compare for 'science' too, which of these gives highest dot product

DF: $f(\bar{x}, y) = f(\bar{x})$ replicated for each class

$f(\bar{x}, y = \text{Health}) = [1, 1, 0, 0\ 0\ 0\ 0\ 0\ 0]$

$f(\bar{x}, y = \text{Sports}) = [0\ 0\ 0\ 1, 1, 0\ 0\ 0\ 0]$

$\bar{w} = [2, 5.6, -3, 1.2, -3.1, 5.7 \ldots]$

single weight vector

Indicator: sentence contains word i AND $y = \text{Sports}$

- Multiclass Perceptron:

for t in epochs:

for i in data:

$y_{pred} = \underset{y}{\text{argmax}}\ \bar{w}_y^T f(\bar{x})$ ← DW

if $y_{pred} \neq y^{(i)}$:

$\bar{w}_{y_{pred}} \leftarrow \bar{w}_{y_{pred}} - \alpha f(\bar{x})$ subtract features for incorrect value of y

$\bar{w}_{y^{(i)}} \leftarrow \bar{w}_{y^{(i)}} + \alpha f(\bar{x})$ Add features for correct value of y

Ex. $[1, 1, 0]$ $y = 1$ Health

- Too many drug trials, too few patients $y = \{1, 2, 3\}$

$[1, 0, 1]$ $y = 2$ Sports

- Baseball players taking drugs

- Assume "default" prediction is $y = 3$

$[\underbrace{0\ 0\ 0}_{\bar{w}_{y_1}}\ \underbrace{0\ 0\ 0}_{\bar{w}_{y_2}}\ \underbrace{0\ 0\ 0}_{\bar{w}_{y_3}}]$

Update on $[1, 1, 0]$ 1

1) $y_{pred} = 3$ $y = 1$ $\alpha = 1$

$[1\ 1\ 0\ \{\ 0\ 0\ 0\ \{\ -1\ -1\ 0]$

Update on $[1, 0, 1]$ 2

2) $y_{pred} = 1$ $y = 2$

$[0, 1, -1\ \{\ 1, 0, 1\ \{\ -1, -1, 0]$