

AdaBoost Machine Learning Algorithms

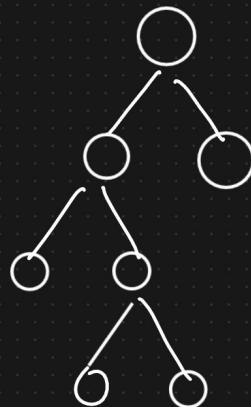
Decision Trees

- {
 } **Bagging**
 {① Random Forest Classifier
 ② Random Forest Regressor}

Decision Tree :

Overfitting = Train Acc ↑
Test Acc ↓

Low Bias
High Variance

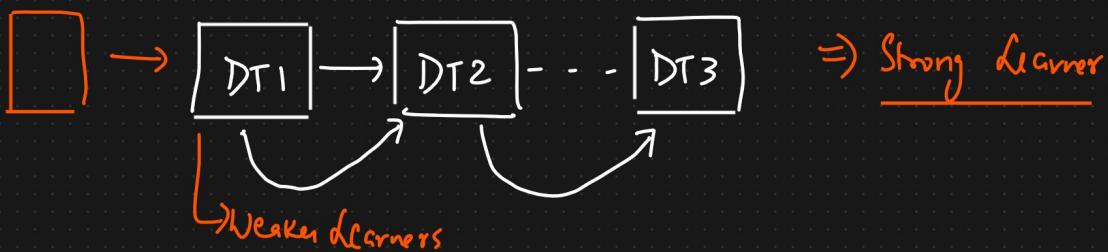


Random Forest { } **Bagging**

{
 } Low Bias
 {
 } Low Variance

Boosting

{ Sequentially connected }



Weak Learner → Haven't learnt much from the
Training Dataset

Random Forest → Majority Voting classifier
Average of (0/p)

Ensemble Techniques

{
 } **weak learners**
 Boosting

- ① AdaBoost
- ② Gradient Boosting
- ③ Xgboost

AdaBoost → Assignment weights to the weak learner

$M_1, \dots, M_n \rightarrow \underline{\text{Decision Tree Stumps}}$

$$f = \alpha_1(M_1) + \alpha_2(M_2) + \alpha_3(M_3) + \dots + \alpha_n(M_n)$$

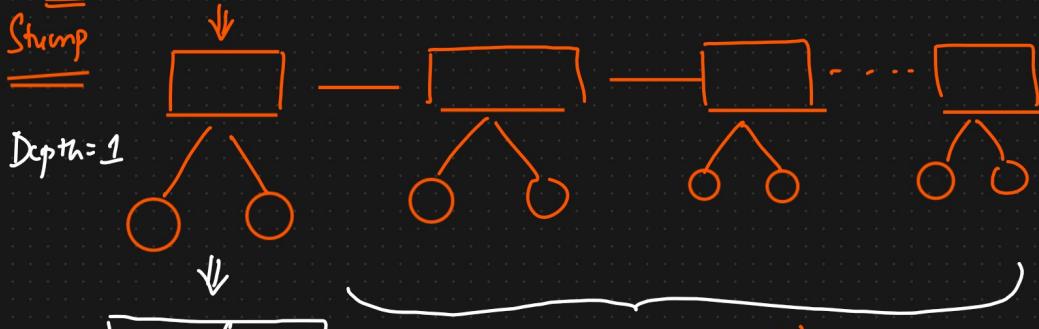
$\{\alpha_1, \alpha_2, \alpha_3, \dots, \alpha_n\} \Rightarrow \text{weights}$

→ CLASSIFICATION

→ REGRESSION

Decision

Stump



↳ Underfitting

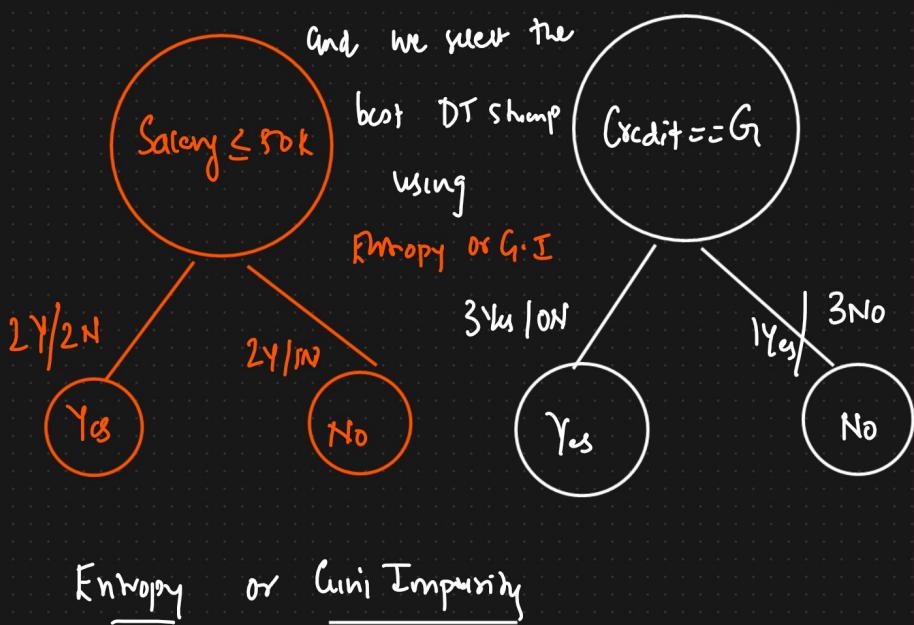
↳ Train Acc ↓ 40%
↳ Test Acc ↑ 45%

Decision Tree Stump

$$\left\{ \begin{array}{l} \text{High Bias} \\ \text{Low Variance} \end{array} \right\} \Rightarrow \left\{ \begin{array}{l} \text{Low Bias} \\ \text{High Variance} \end{array} \right\}$$

AdaBoost Classifier Maths Indepth Intuition ① We create Decision Tree Stump

Salary	Credit	Approval
$\leq 50K$	B	No
$\leq 50K$	G	Yes
$\leq 80K$	G	Yes
$> 50K$	B	No
$> 50K$	G	Yes
$> 50K$	N	Yes
$\leq 50K$	N	No.



$$H(S) = -P_+ \log_2 P_+ - P_- \log_2 P_-$$

(2) Sum of the Total Errors And Performance of Stump

Sum of all the
① Total Error
= $\frac{1}{7}$

Salary	Credit	Approval	Sample Weights
$\leq 50K$	B	No.	$\frac{1}{7}$
$\leq 50K$	G	Yes	$\frac{1}{7}$
$\leq 50K$	G	Yes	$\frac{1}{7}$
$> 50K$	B	No	$\frac{1}{7}$
$> 50K$	G	Yes	$\frac{1}{7}$
$ > 50K$	N	Yes	$\frac{1}{7}$
$\leq 50K$	N	No.	$\frac{1}{7}$

② Performance of Stump = $\frac{1}{2} \ln \left[\frac{1 - TE}{TE} \right]$

$= \frac{1}{2} \ln \left[\frac{1 - \frac{1}{7}}{\frac{1}{7}} \right]$

$= \frac{1}{2} \ln [6] \approx 0.896$

Performance of Stump ≈ 0.896

$$f = d_1(M_1) + d_2(M_2) + \dots + d_n(M_n)$$

$$d_1 = 0.896 \Rightarrow \text{Weight}$$

For correct classified points

- Performance of Stump

$$= \text{weight} * e^{-(0.896)}$$

$$= \frac{1}{7} * e^{-(0.896)}$$

$$= 0.058$$

For Incorrect classified

- Performance of Stump

$$= \text{weight} * e^{(0.896)}$$

$$= \frac{1}{7} * e^{(0.896)}$$

(3) Update the weights for correctly and Incorrectly classified points

Salary	Credit	Approval	Sample Weights	update wts	For correct classified points
$\leq 50K$	B	No.	$\frac{1}{7} \downarrow$	0.058	$= \text{weight} * e^{-0.058}$
$\leq 50K$	G	Yes	$\frac{1}{7} \downarrow$	0.058	$= \frac{1}{7} * e^{-0.058}$
$\leq 50K$	G	Yes	$\frac{1}{7} \downarrow$	0.058	$= 0.058$
$> 50K$	B	No	$\frac{1}{7} \downarrow$	0.058	
$> 50K$	G	Yes	$\frac{1}{7} \downarrow$	0.058	
$ > 50K$	N	Yes	$\frac{1}{7} \uparrow$	0.349	For Incorrect classified
$\leq 50K$	N	No.	$\frac{1}{7} \downarrow$	0.058	$= \text{weight} * e^{0.058}$

$$= 0.349$$

④ Normalized Weights Computation And Assigning Bins

Salary	Credit	Approval	Update Wts	Normalized Weights	Bins Assignment
$\leq 50K$	B	No.	0.058	0.08	0 - 0.08
$\leq 50K$	G	Yes	0.058	0.08	0.08 - 0.16
$\leq 50K$	G	Yes	0.058	0.08	0.16 - 0.24
$> 50K$	B	No	0.058	0.08	0.24 - 0.32
$> 50K$	G	Yes	0.058	0.08	0.32 - 0.40
$ > 50K$	N	Yes	0.349	0.50	0.40 - 0.70
$\leq 50K$	N	No.	0.058	0.08	0.50 - 0.58
				<u>0.697</u>	<u>≈ 1</u>



$\delta_1 = 0.896$ Prepare
datapoints

⑤ Select data points to send to Next Step

Salary	Credit	Approval	Bins Assignment
$\leq 50K$	B	No.	0 - 0.08
$\leq 50K$	G	Yes	0.08 - 0.16
$\leq 50K$	G	Yes	0.16 - 0.24
$> 50K$	B	No	0.24 - 0.32
$> 50K$	G	Yes	0.32 - 0.40
$ > 50K$	N	Yes	0.40 - 0.70
$\leq 50K$	N	No.	0.50 - 0.58

① Iteration process selecting random value between 0 and 1

S	Credit	Approval	Random
$ > 50K$	N	Yes	0.50
$\leq 50K$	G	Yes	0.10
$> 50K$	N	Yes	0.60
$> 50K$	N	Yes	0.75
$\leq 50K$	G	Yes	0.24
$> 50K$	B	No.	0.32
$> 50K$	N	Yes	0.87

⑥ Then records will be sent to next DT stump.

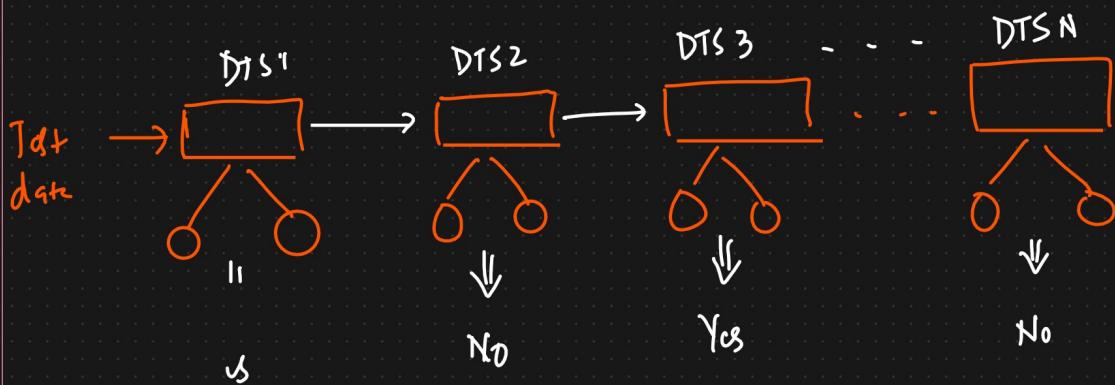
S	Credit	Approve	Sample weight	
>50K	N	Yes	$\frac{1}{6}$	TE
<=50K	G	Yes	$\frac{1}{6}$	Performance Stump $\Rightarrow 0.65$
>50K	N	Yes	$\frac{1}{6}$	
>50K	N	Yes	$\frac{1}{6}$	
<=50K	G	Yes	$\frac{1}{6}$	
>50K	B	No	$\frac{1}{6}$	
>50K	N	Yes	$\frac{1}{6}$	

$f_1 = f_1(M_1) + f_2(M_2)$

$$\begin{array}{c} f_1 = 0.896 \\ \hline \end{array} \quad \begin{array}{c} f_2 = 0.65 \\ \hline \end{array}$$

⑦ Final Prediction

Test data ($\leq 50K, G$)



$$f_1 = 0.896 \quad f_2 = 0.65 \quad f_3 = 0.24 \quad f_n = -0.30$$

$$\begin{aligned} f &= f_1(M_1) + f_2(M_2) + f_3(m_3) + \dots + f_4(m_4) \\ &= 0.896(Yes) + (0.65)(No) + 0.24(Yes) - 0.30(No) \end{aligned}$$

$1.0 \cdot \frac{1}{6}$
 $0.65 \cdot \frac{1}{6}$
 $0.24 \cdot \frac{1}{6}$
 $-0.30 \cdot \frac{1}{6}$
 \hline
 1.136

$$= \boxed{1.136} (\gamma_u) + 0.350 (N_0) \Rightarrow \underline{\underline{O/P}} : \underline{\underline{\gamma_u}}$$

Performance of say (γ_u) = 1.136

Performance of say (N_0) = 0.350