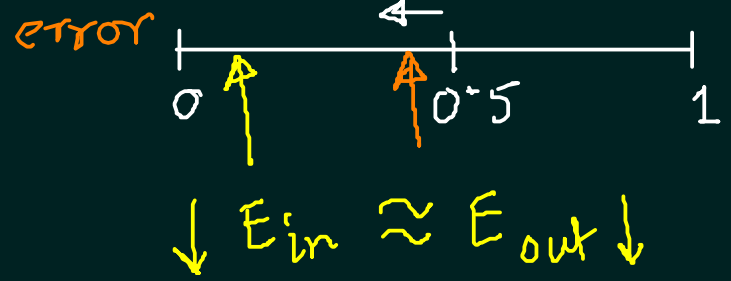


Weak Learners $\epsilon < 0.5$

2-class Classification



$\rightarrow L_1 L_2 L_3 \dots$

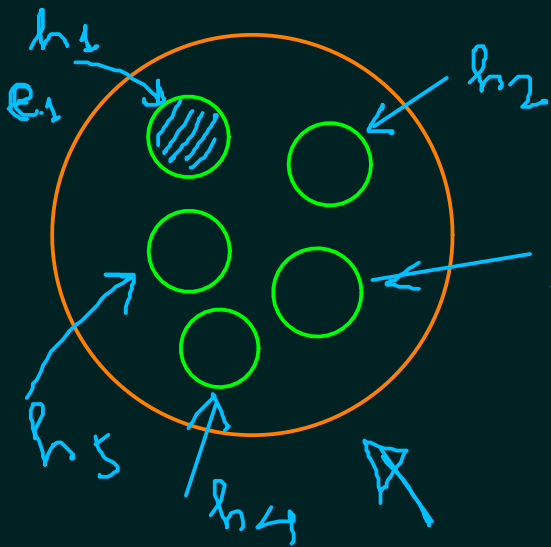
Multiple Learner: $\begin{cases} L_1 & L_3 \\ L_2 & L_4 \dots \end{cases}$

\leftarrow Different Algorithm (SVM, PLA, DTL, CL) =

\leftarrow Different Hyperparameters $[w_i \dots]$

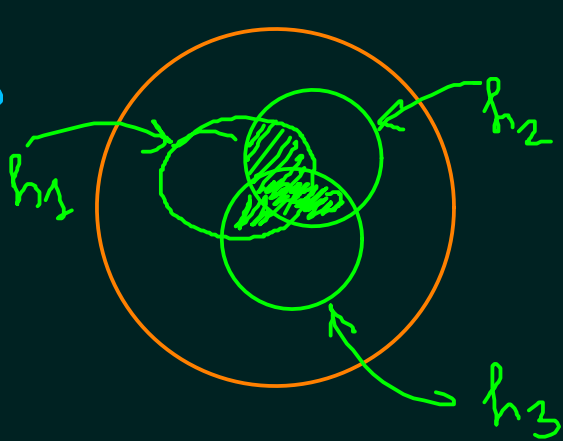
\leftarrow Different Training Set $\rightarrow D = \underline{D}_1 \cup \underline{D}_2 \cup \underline{D}_3 \cup \dots$

\leftarrow Different Representation (/ Prob)

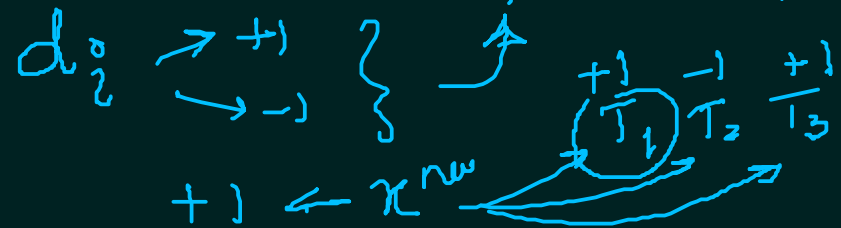


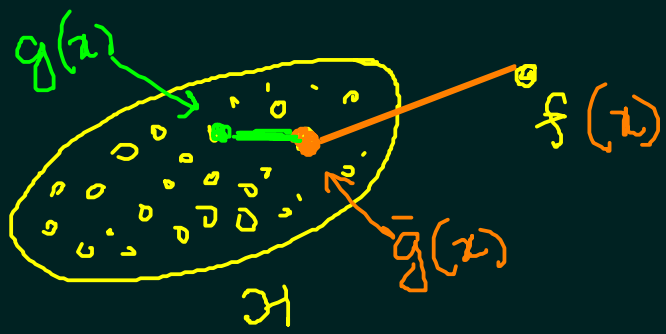
\rightarrow Ensemble Learning

\rightarrow Combine Multiple (Weak) Learners



\rightarrow How much independent?





↑ bias
↓ var } Σ

n independent learners

$$E = 0.3 \rightarrow \underline{Acc} = 0.7$$

$$n_1 + n_2 = n, n_1 > n_2 \rightarrow \text{majority}$$

$$\text{Prob}[\text{Class}(n_1)] = 1 - B(n, n_2, 0.7)$$

$$B(n, r, p) = \sum_{i=r}^n \binom{n}{i} p^i (1-p)^{n-i}$$

→ Combina

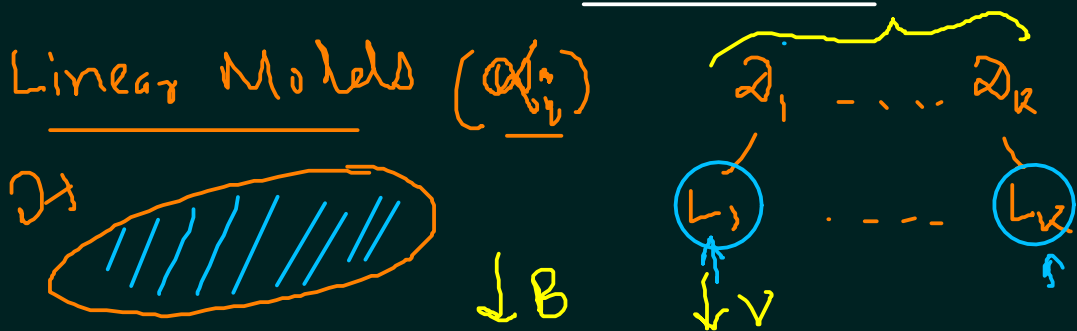
majority → unweighted
→ weighted

$$\propto Acc$$

$$\propto \frac{1}{var}$$

$$y = \sum_{i=1}^k w_i d_i, \quad \left. \begin{array}{l} w_i \geq 0 \text{ and} \\ \sum_i w_i = 1 \end{array} \right\}$$

$$Var(y) = Var\left(\sum_j \frac{1}{k} d_j\right) = \frac{1}{k^2} \cdot k Var(d_j) = \frac{Var(d_j)}{k}$$



3, $E = 0.3$ 0.7

$$\textcircled{2} \left[1 - 3 \binom{3}{2} 0.7^1 (1-0.7)^2 \right]$$

$$\text{Prob}(C_i | x) = \sum_{\text{all } M_j} \underbrace{P(C_i | x, M_j)}_{\checkmark} \cdot \underbrace{P(M_j)}_{\checkmark, \text{Prior}} \cdot w_i$$

$\left\{ \begin{array}{l} M_1 \leftarrow \\ \vdots \\ M_k \leftarrow \end{array} \right.$

$$y = \underset{C_j \in C}{\text{argmax}} \sum_{h_i \in H} P(C_j | h_i) \cdot P(TE | h_i) \cdot P(h_i)$$

→ **BMA** → MC Sim

Independent Learner :-

$$\text{Var}(y) = \frac{\text{Var}(d_j)}{K} \leftarrow \text{ind.}$$

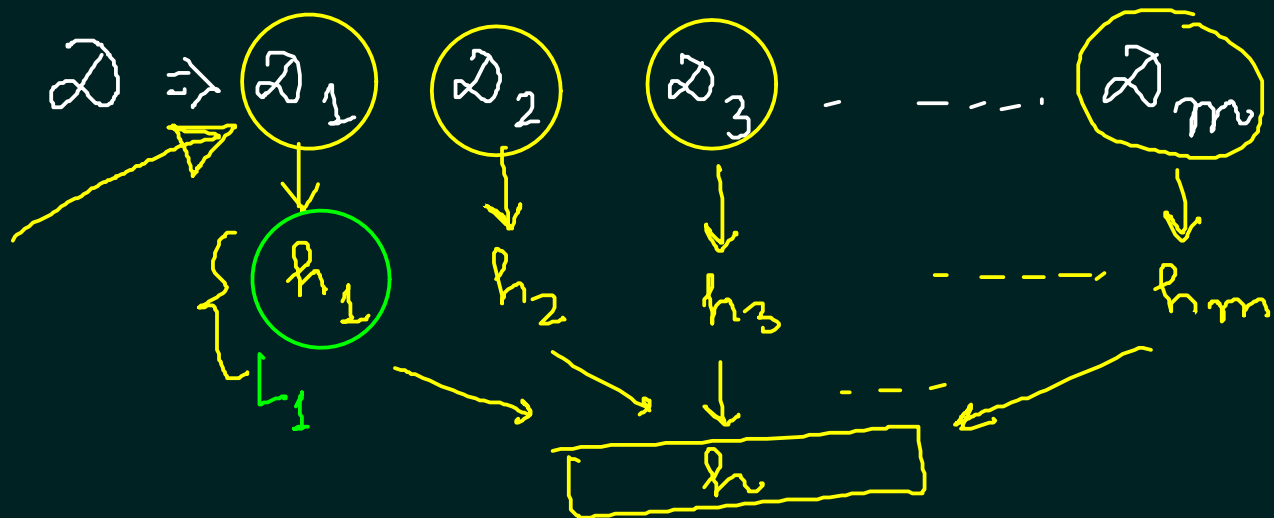
$$\text{Var}(y) = \text{Var}\left(\sum_j \frac{1}{K} d_j\right)$$

$$= \frac{1}{K^2} \left[\underbrace{\sum_j \text{Var}(d_j)}_{\checkmark} + 2 \sum_i \sum_j \underbrace{\text{Cov}(d_i, d_j)}_{\text{??}} \right]$$

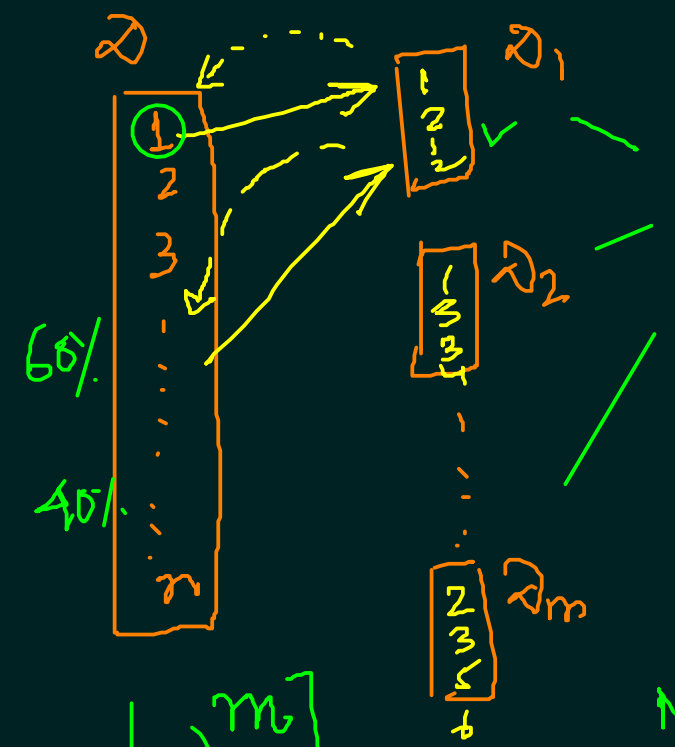
W/O Cov

→ How to make / produce **Independent Learners?**

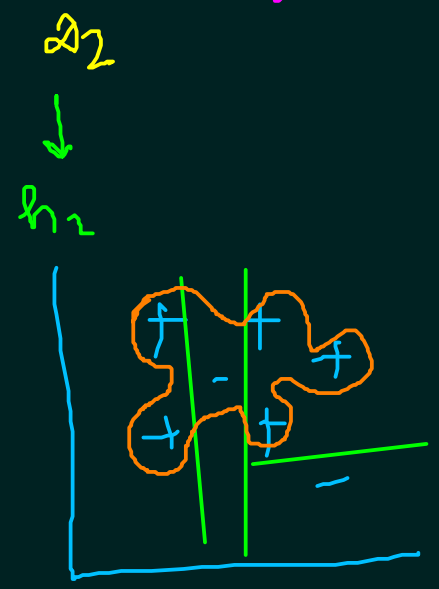
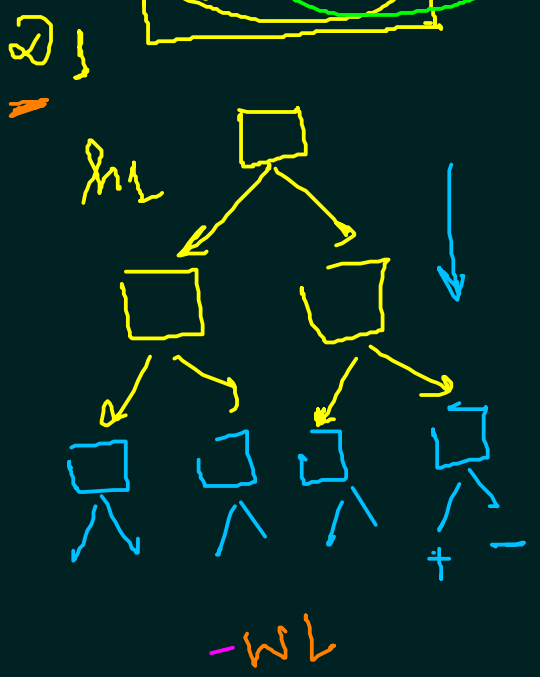
$\left[\begin{array}{l} \text{Var}(x) = ? \dots \dots \dots \\ \text{Var}(x_1 + x_2) = \dots \dots \dots \end{array} \right]$	$E(x) = \int x f(x) dx$
--	-------------------------



BAGGING



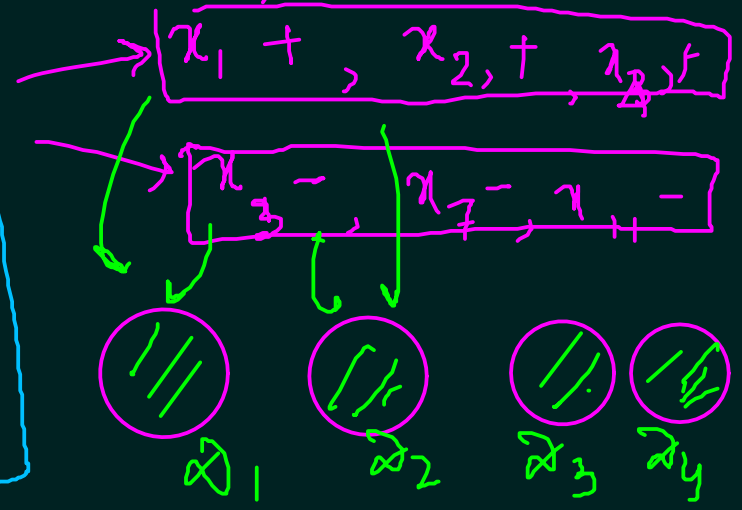
Random Forest (Ensemble DT)



$$\left[1 - \left(1 - \frac{1}{n} \right)^m \right]$$

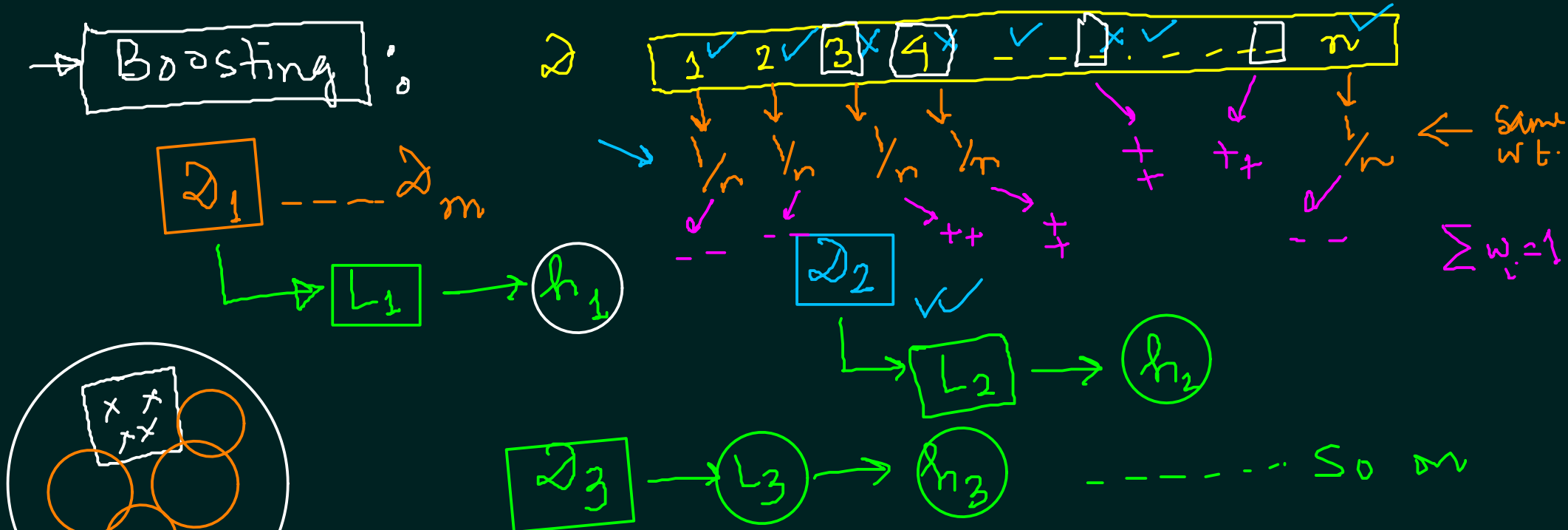
- $x_{1,+}$
- $x_{2,+}$
- $x_{3,-}$
- $x_{4,+}$

Math2



Met1 Bootstrapping

Boosting:



ADABOOST

Ensemble

Weak Algo \Rightarrow Strong Learner



Independent learners \Rightarrow

Bagging $\xrightarrow{\text{Bootstrap Sample (Stratified)}}$
 Boosting \rightarrow ADABOOST!!