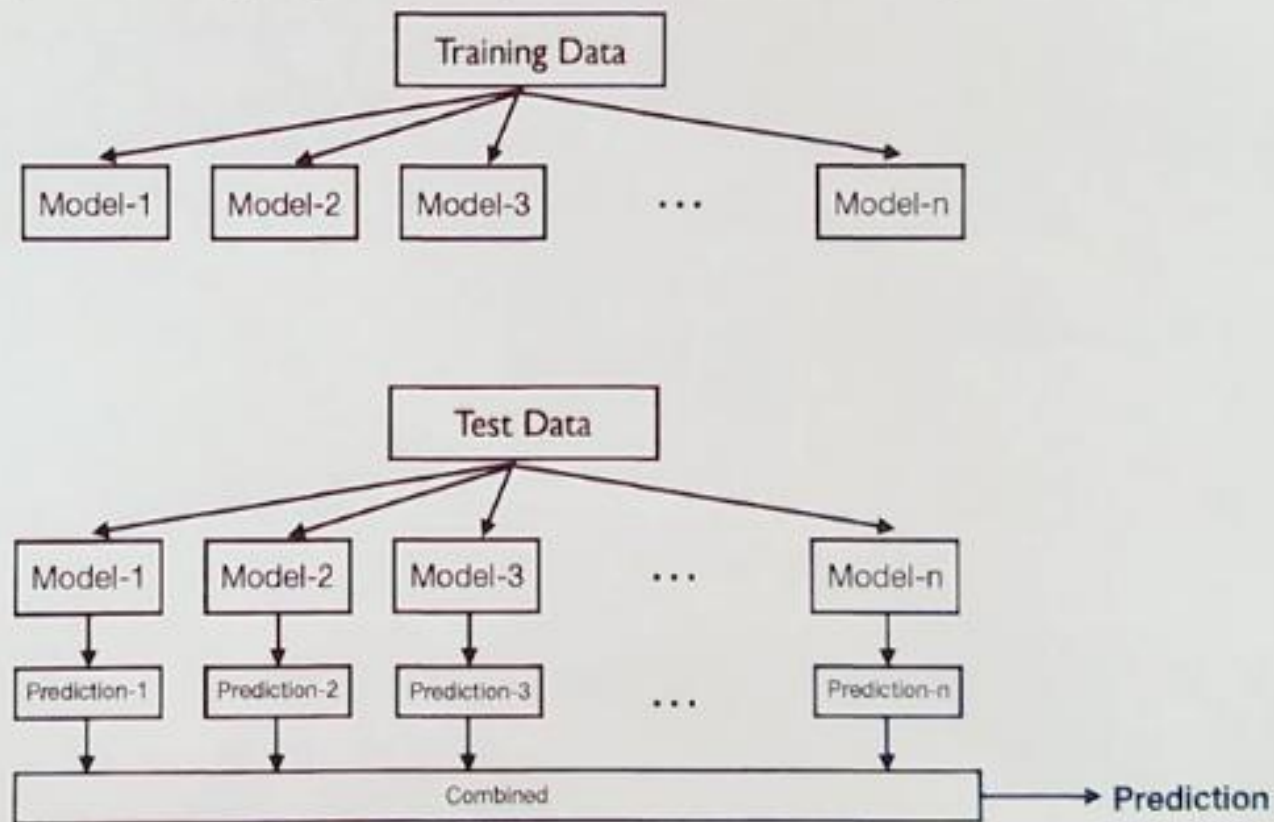


# Ensemble Methods

- Ensembles are machine learning methods for combining predictions from multiple separate models.
- The central motivation is rooted under the belief that a committee of experts working together can perform better than a single expert.

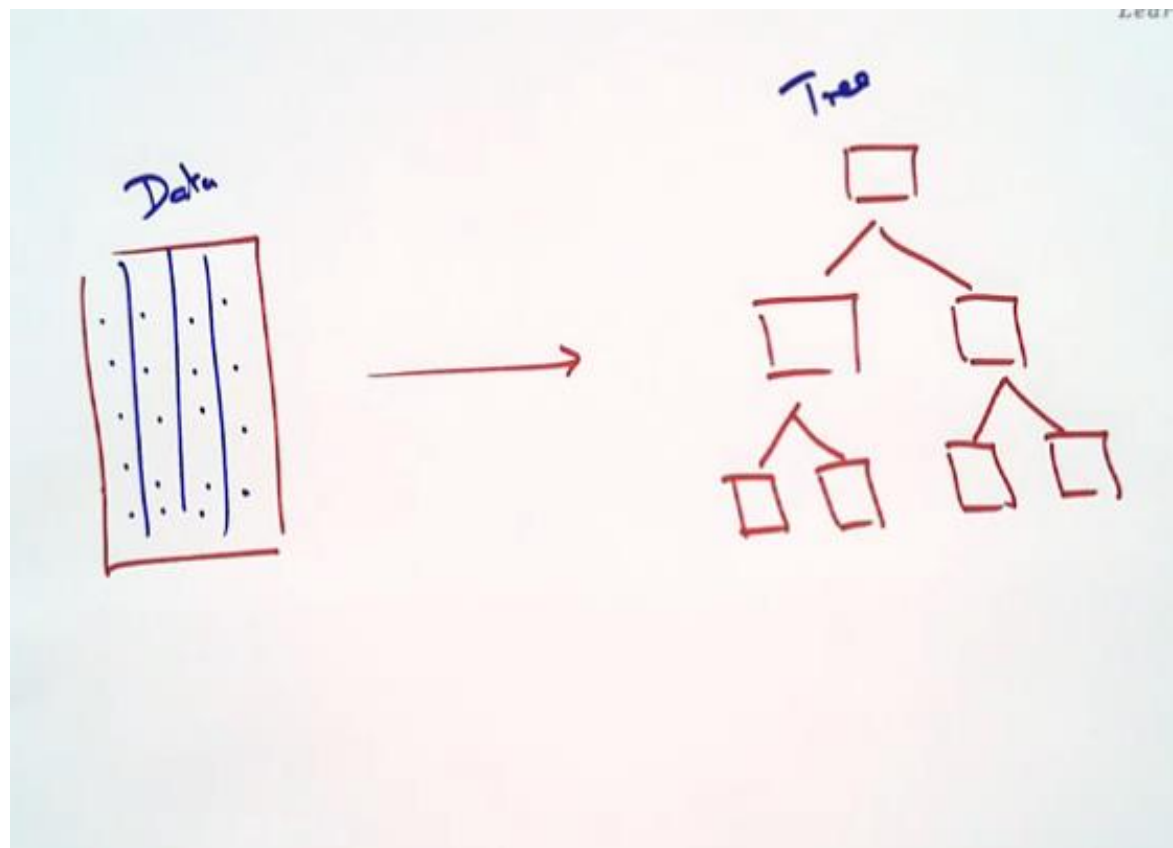


# Example

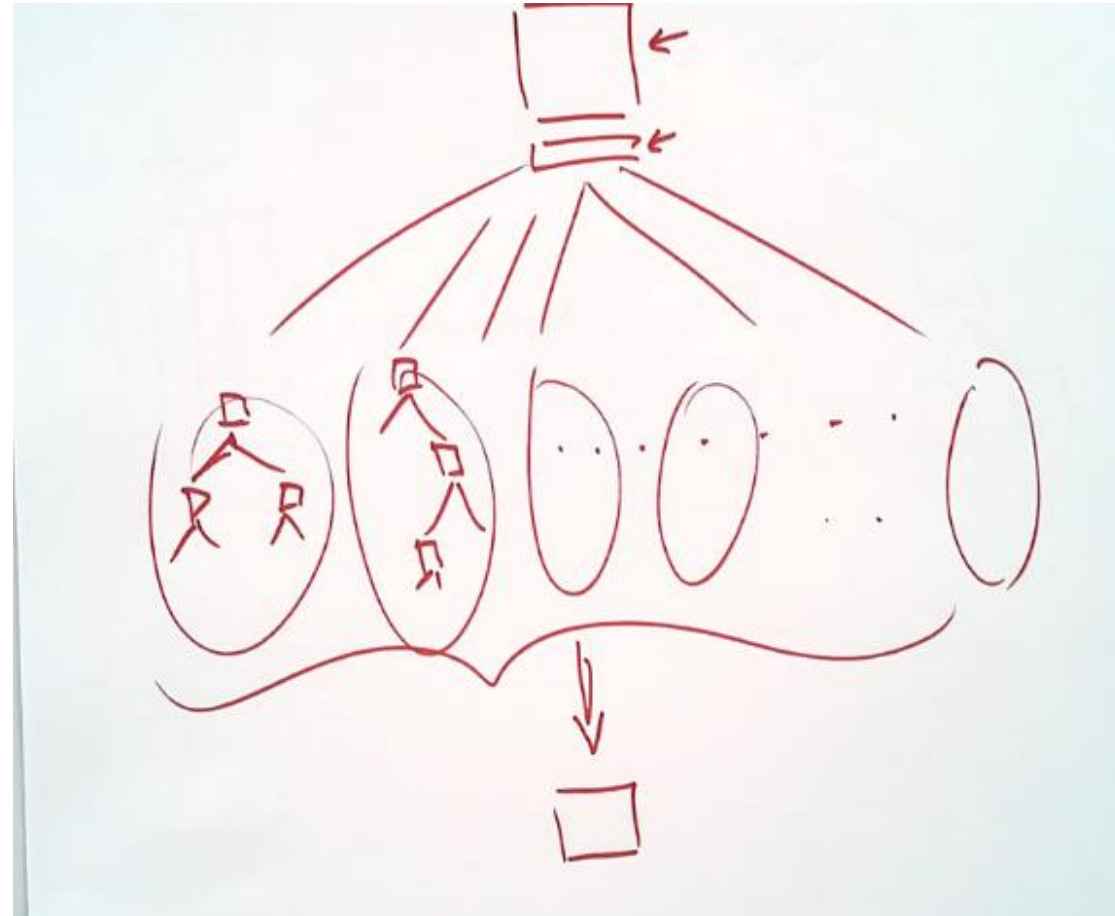
Handwritten matrix diagram showing relationships between machines  $M_1, M_2, M_3, \dots, M_{10}$  and a set of tasks. The columns are labeled  $M_1, M_2, M_3, \dots, M_{10}$  with  $90\%$  above each. The rows are labeled with tasks, with  $70\%$  above the first row. Red checkmarks ( $\checkmark$ ) and crosses ( $\times$ ) indicate task-machine compatibility. Green and red arcs connect specific machines to tasks.

	$M_1$	$M_2$	$M_3$	$\dots$	$M_{10}$
Task 1	$\checkmark$	$\checkmark$	$\checkmark$		$\checkmark$
Task 2	$\checkmark$	$\times$	$\times$		$\checkmark$
Task 3	$\checkmark$	$\checkmark$	$\checkmark$		$\times$
Task 4	$\times$	$\checkmark$	$\times$		$\checkmark$
Task 5	$\checkmark$	$\times$	$\checkmark$	$\dots$	$\checkmark$
Task 6	$\times$	$\checkmark$	$\checkmark$		$\checkmark$
Task 7	$\dots$	$\dots$	$\dots$		$\dots$
Task 8	$\checkmark$	$\times$	$\checkmark$		$\times$

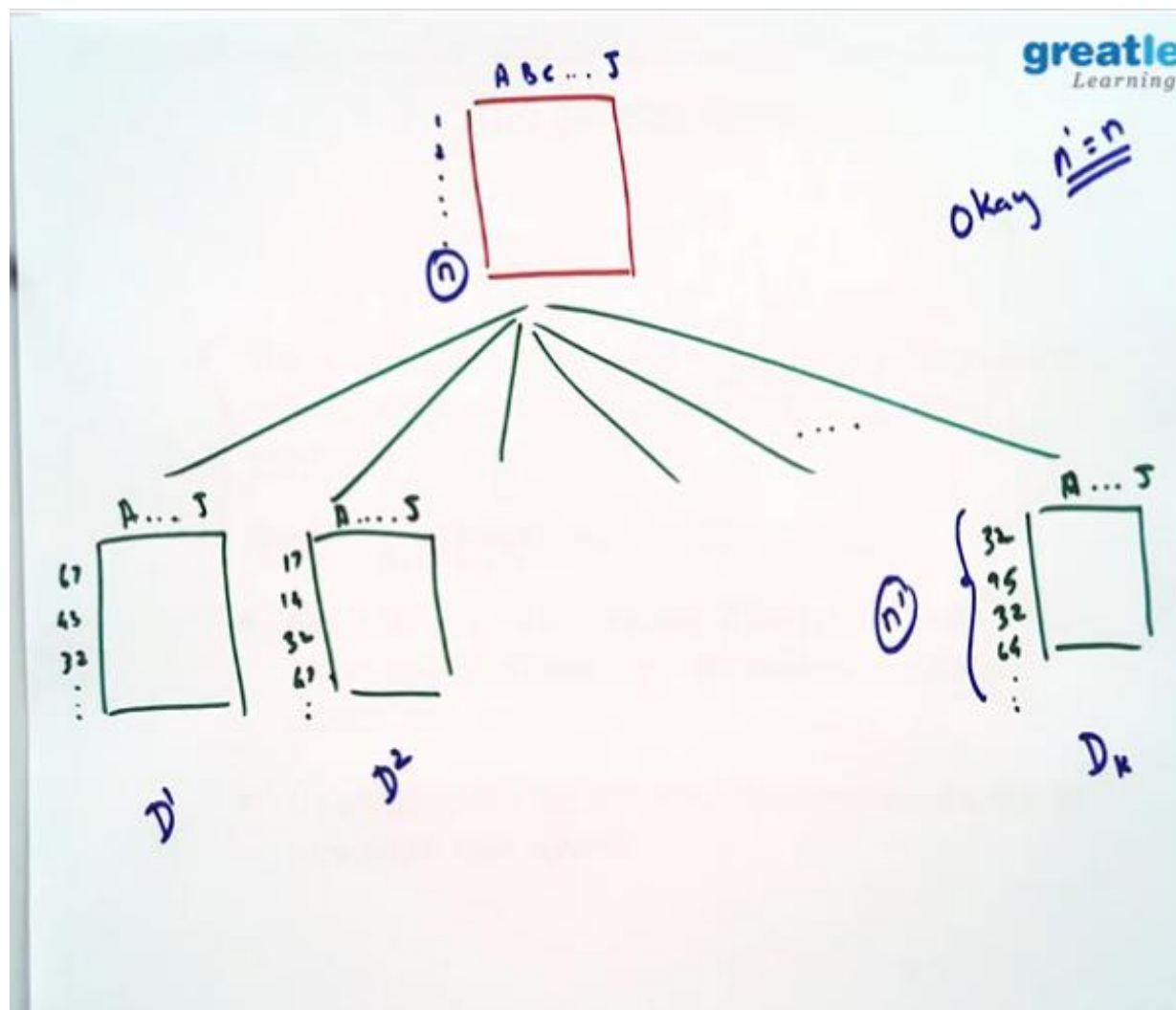
# Random Forest



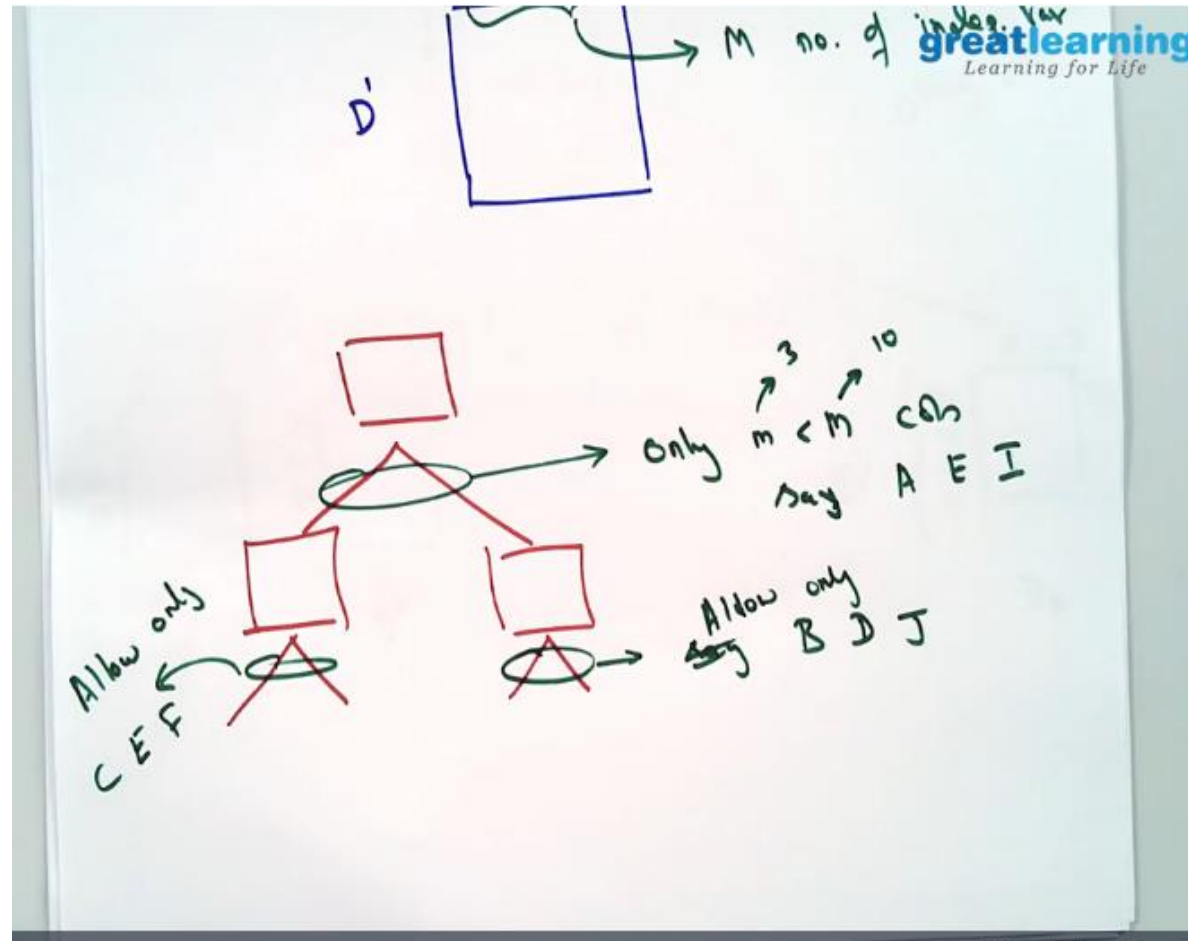
# Random Forest



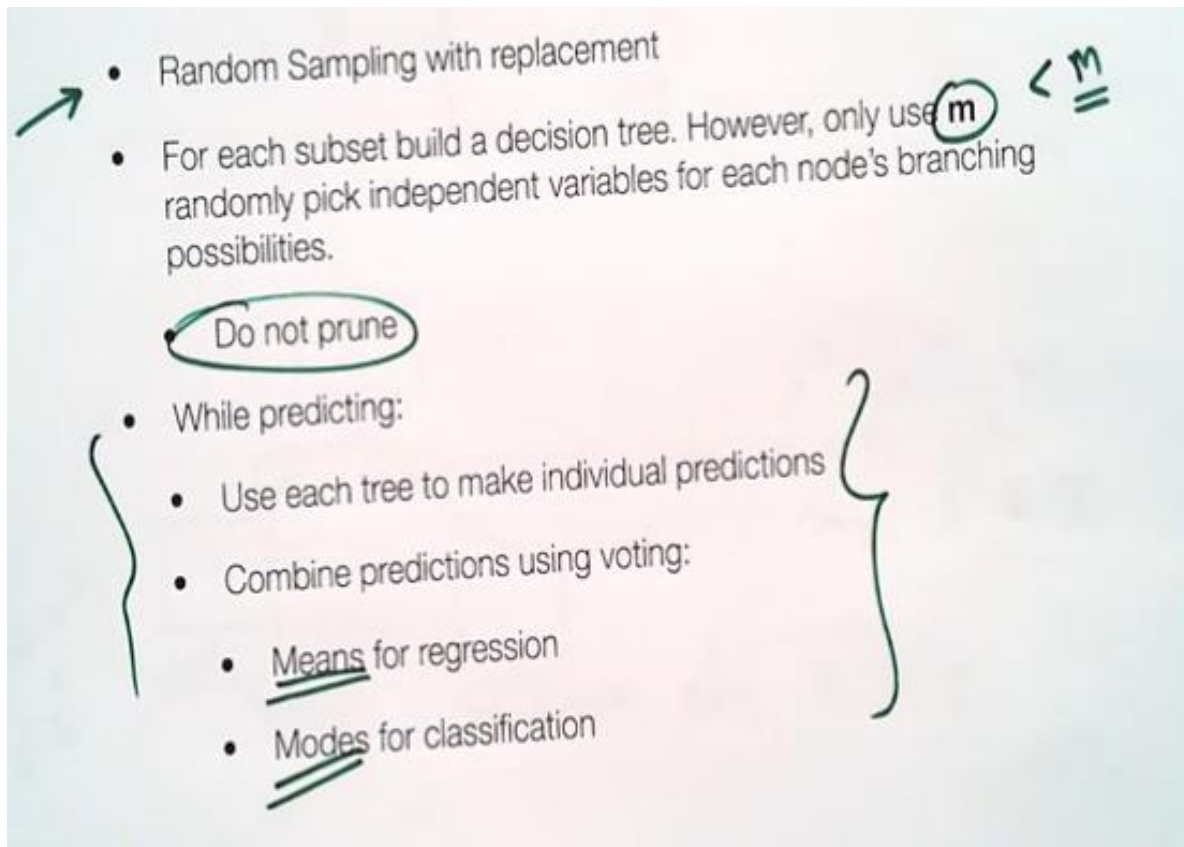
# Random Forest



# Random Forest



# Random Forest

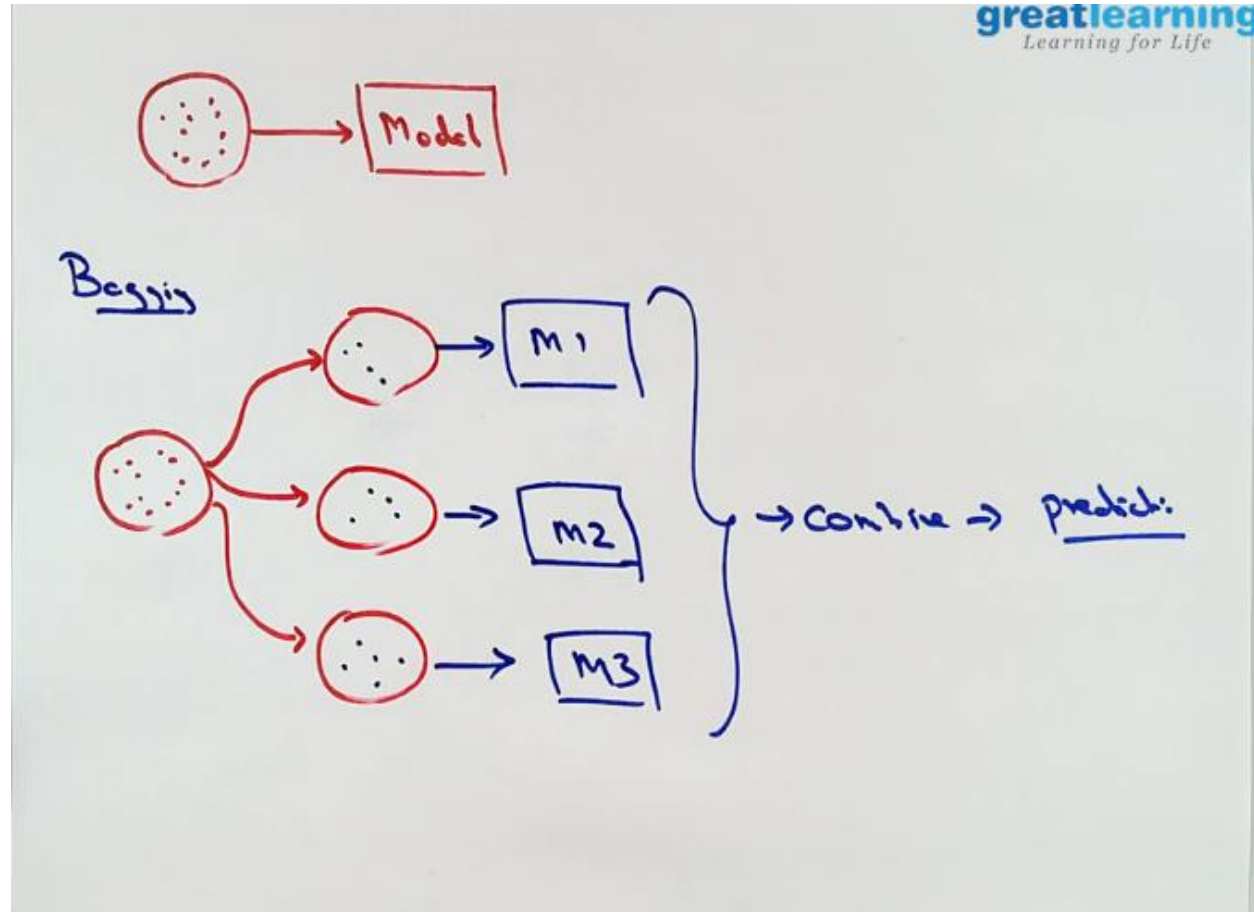
- 
- Random Sampling with replacement
  - For each subset build a decision tree. However, only use  $m$   $< M$  randomly pick independent variables for each node's branching possibilities.
  - Do not prune
  - While predicting:
    - Use each tree to make individual predictions
    - Combine predictions using voting:
      - Means for regression
      - Modes for classification



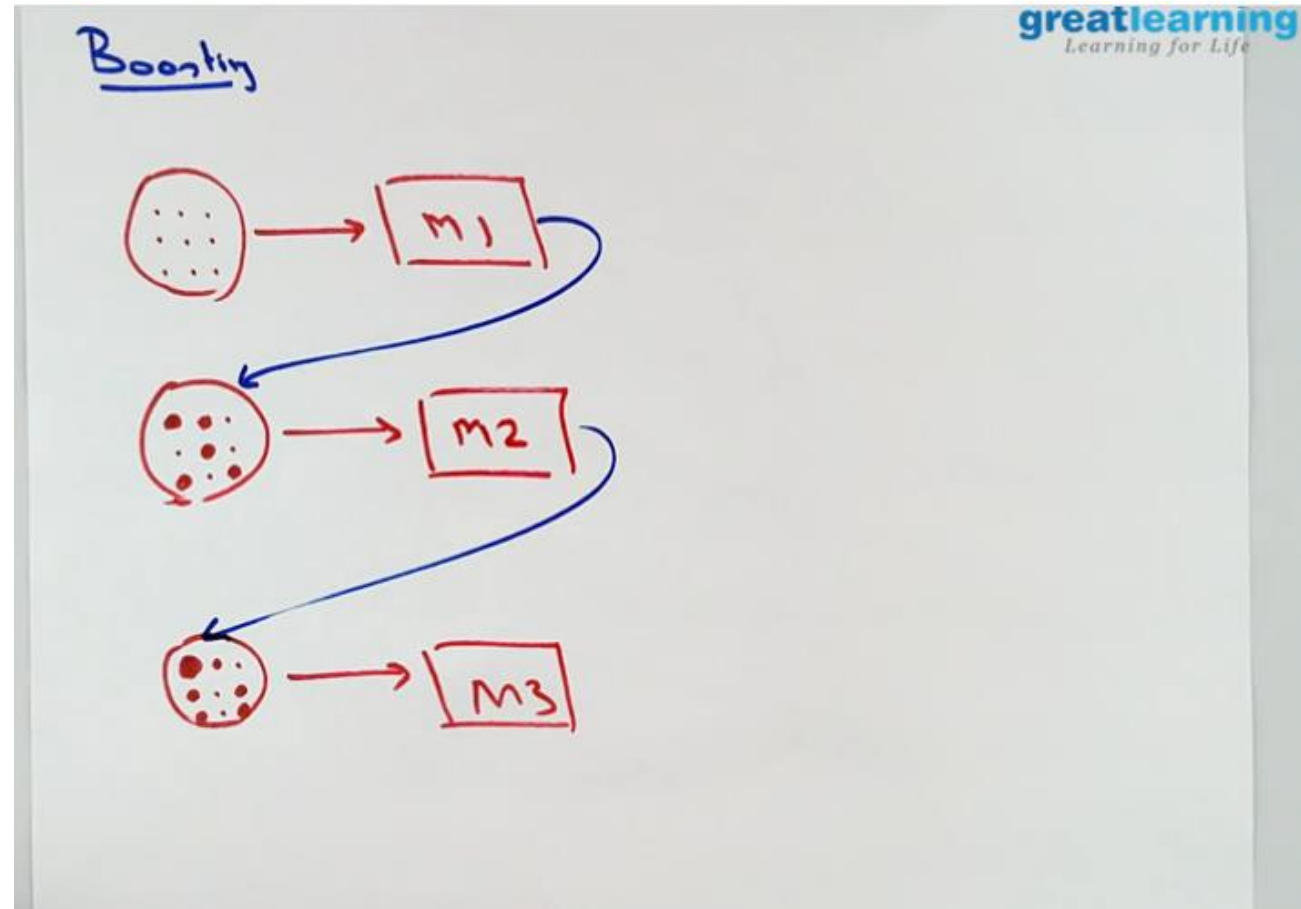




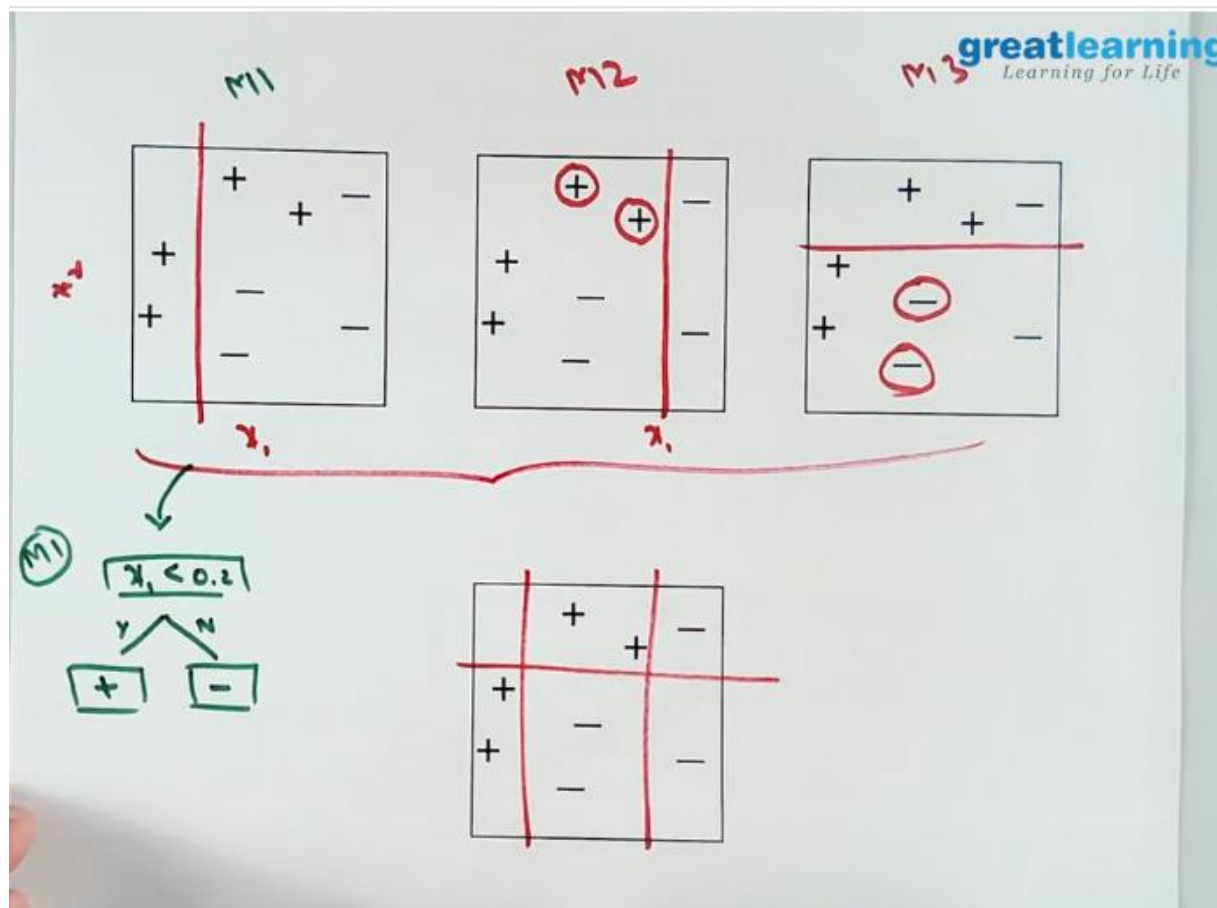
# Bagging



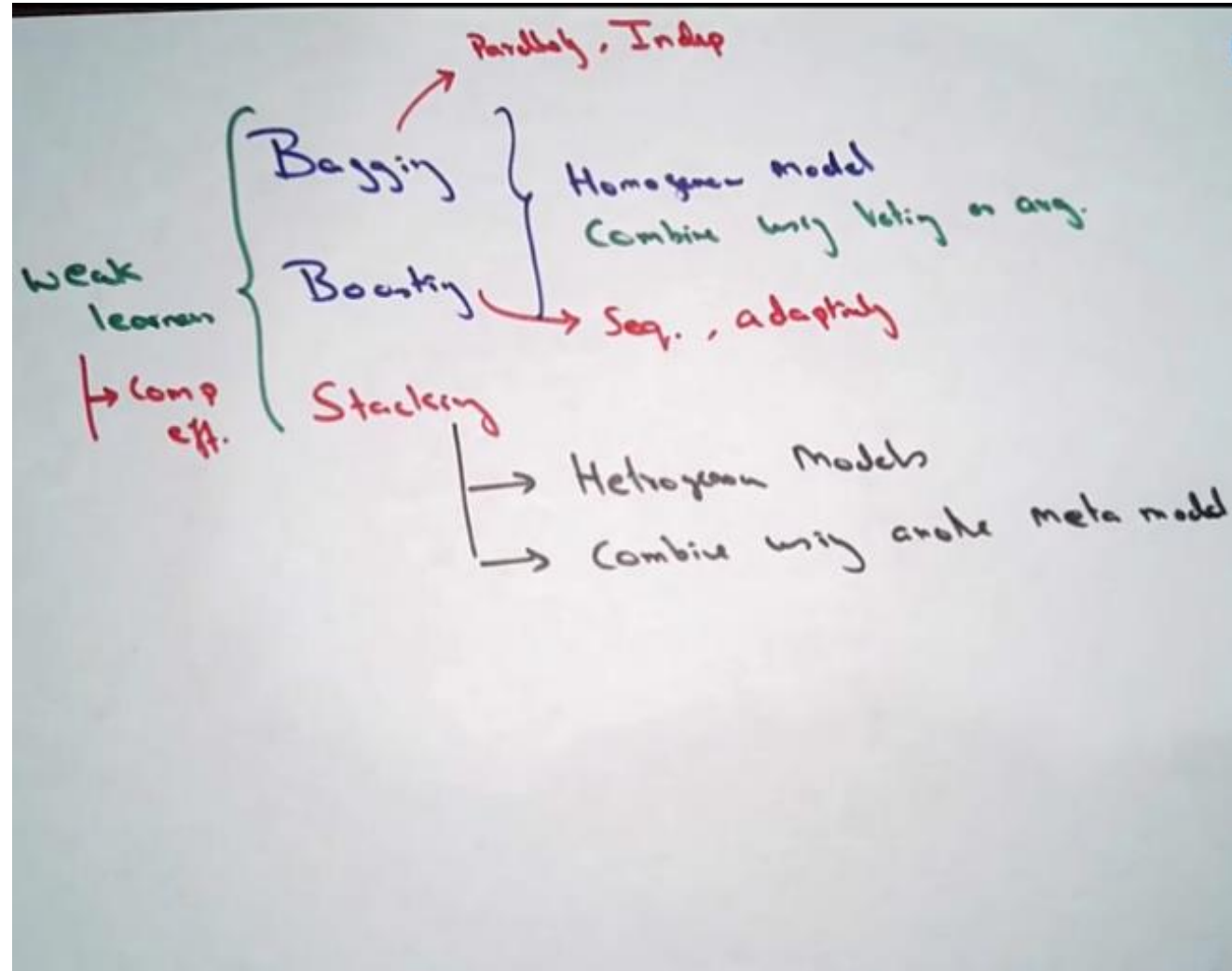
# Boosting



# Boosting – Visual Example



# Stacking



# Stacking

