AI VIET NAM
@aivietnam.edu.vn

Module 03 – Extra Class

RANDOM FOREST

Nguyen Quoc Thai

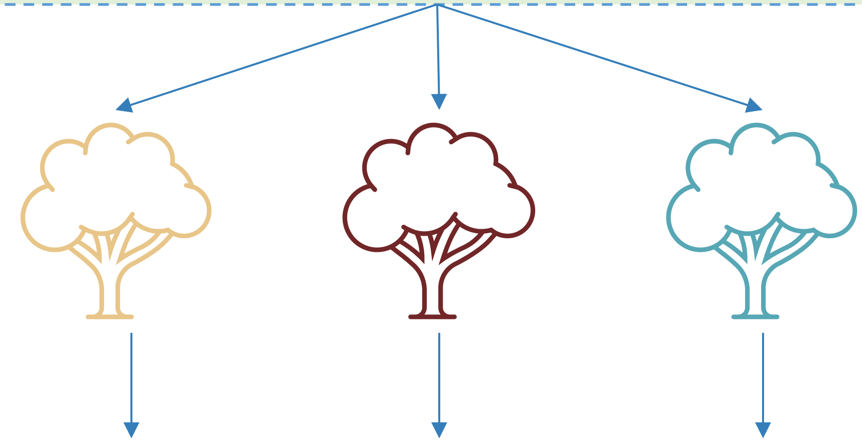
Objectives

Decision Tree Review

- ❖ Decision Tree
- ❖ Decision Tree for Classification
- ❖ Decision Tree for Regression
- ❖ IRIS Classification
- ❖ Salary Prediction

Random Forest

- ❖ Decision Tree
- ❖ Random Forest
  - Bootstrap Sample
  - Majority Voting / Averaging
- ❖ IRIS Classification
- ❖ Salary Prediction



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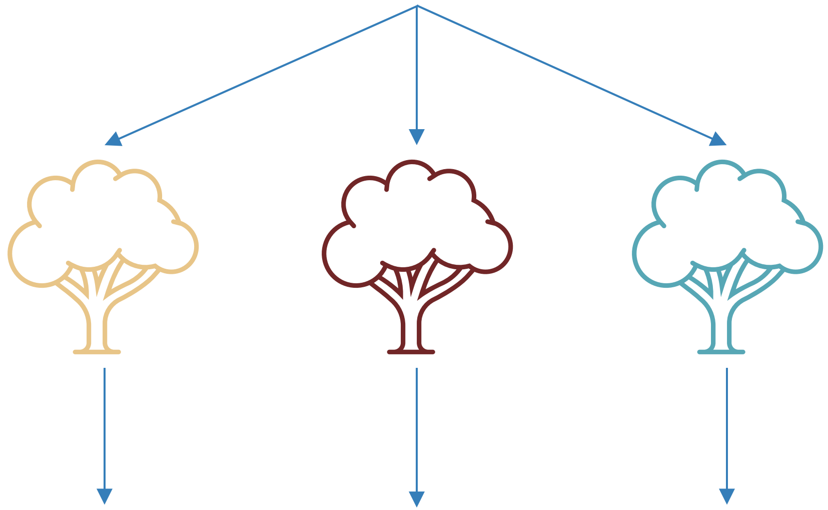
Outline

SECTION 1

Decision Tree Review

SECTION 2

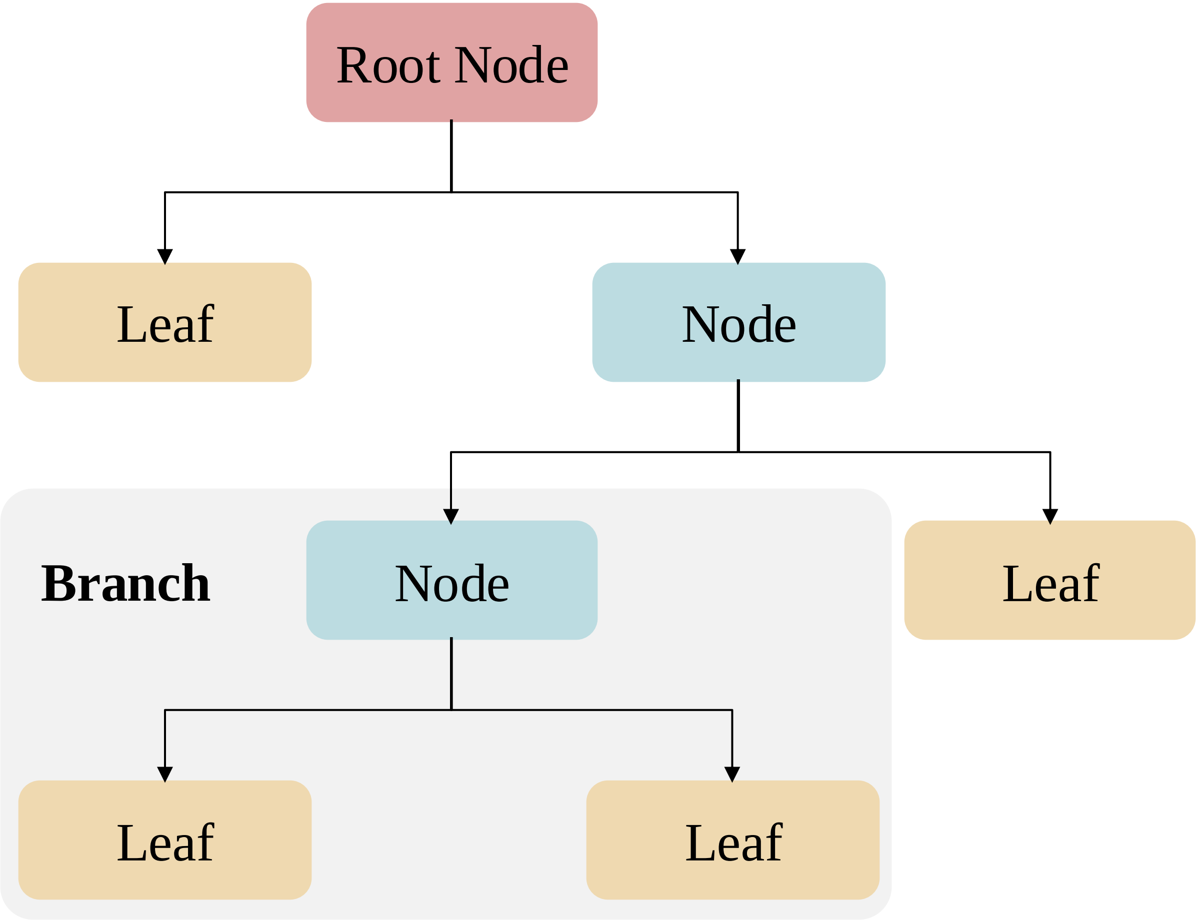
Random Forest



Decision Tree Review

Decision Tree

- **Root Node**: the top-level node
- **Node**: internal node or decision node
- **Parent Node**: a node that precedes a (child) node
- **Leaf**: terminal node – a node at the end of a branch – represents outcome of the tree (label or numerical value)
- **Branches**: a subset of a tree, starting at an (internal) node until the leaves



Decision Tree Review

Decision Tree for Classification

$$Gini(D) = \frac{n_1}{n} Gini(D_1) + \frac{n_2}{n} Gini(D_2)$$

$$Gini(D_i) = 1 - \sum_{j=1}^{c} p_j^2$$

$$D = \{3-, 3+\}$$

$$Gini(D) = 1 - \left(\frac{3}{3+3}\right)^2 - \left(\frac{3}{3+3}\right)^2 = \frac{1}{2}$$

Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

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Decision Tree Review

Decision Tree for Classification

$$Gini(D) = \frac{n_1}{n} Gini(D_1) + \frac{n_2}{n} Gini(D_2)$$

$$Gini(D_i) = 1 - \sum_{j=1}^{c} p_j^2$$

Numerical Feature	Ascending Ordering	Calculate mean	Determine Gini

Petal_Length
0.9
1
1.2
1.3
1.7
1.8

0.95
1.1
1.25
1.5
1.75

$Gini(Length \leq 0.95)$

$Gini(Length \leq 1.1)$

$Gini(Length \leq 1.25)$

$Gini(Length \leq 1.5)$

$Gini(Length \leq 1.75)$

Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

Decision Tree Review

Decision Tree for Classification

$$Gini(D) = \frac{n_1}{n} Gini(D_1) + \frac{n_2}{n} Gini(D_2)$$

$$Gini(D_i) = 1 - \sum_{j=1}^{c} p_j^2$$

$$D = \{3-, 3+\}$$

True / False: Length $\leq$ 1.1

$$D_1 = \{2-, 0+\} \qquad D_2 = \{1-, 3+\}$$

$$Gini(D_1) = 1 - \left(\frac{2}{2+0}\right)^2 - \left(\frac{0}{2+0}\right)^2 = 0$$

$$Gini(D_2) = 1 - \left(\frac{1}{1+3}\right)^2 - \left(\frac{3}{1+3}\right)^2 = \frac{3}{8}$$

$$Gini(Length \leq 1.1) = \frac{2}{6} * 0 + \frac{4}{6} * \frac{3}{8} = \frac{1}{4}$$

Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

Decision Tree Review

Decision Tree for Classification

$$Gini(D) = \frac{n_1}{n} Gini(D_1) + \frac{n_2}{n} Gini(D_2)$$

$$Gini(D_i) = 1 - \sum_{j=1}^{c} p_j^2$$

$D = \{3-, 3+\}$

True

False

Length $\leq$ 1.5

Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

Decision Tree Review

Decision Tree for Classification

$$Gini(D) = \frac{n_1}{n} Gini(D_1) + \frac{n_2}{n} Gini(D_2)$$

$$Gini(D_i) = 1 - \sum_{j=1}^{c} p_j^2$$

Numerical Feature	Ascending Ordering	Calculate mean	Determine Gini

Petal_Width	
0.2	0.35
0.5	0.55
0.6	0.65
0.7	0.8
0.9	1.1
1.3	

$Gini(Width \leq 0.35)$

$Gini(Width \leq 0.55)$

$Gini(Width \leq 0.65)$

$Gini(Width \leq 0.8)$

$Gini(Width \leq 1.1)$

Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

Decision Tree Review

Decision Tree for Classification

$$Gini(D) = \frac{n_1}{n} Gini(D_1) + \frac{n_2}{n} Gini(D_2)$$

$$Gini(D_i) = 1 - \sum_{j=1}^{c} p_j^2$$

$D = \{3-, 3+\}$

True | False

Width $\leq$ 0.55

$D_1 = \{1-, 1+\}$

$D_2 = \{2-, 2+\}$

$$Gini(D_1) = 1 - \left(\frac{1}{1+1}\right)^2 - \left(\frac{1}{1+1}\right)^2 = \frac{1}{2}$$

$$Gini(D_2) = 1 - \left(\frac{2}{2+2}\right)^2 - \left(\frac{2}{2+2}\right)^2 = \frac{1}{2}$$

$$Gini(Width \leq 0.55) = \frac{2}{6} * \frac{1}{2} + \frac{4}{6} * \frac{1}{2} = \frac{1}{2}$$

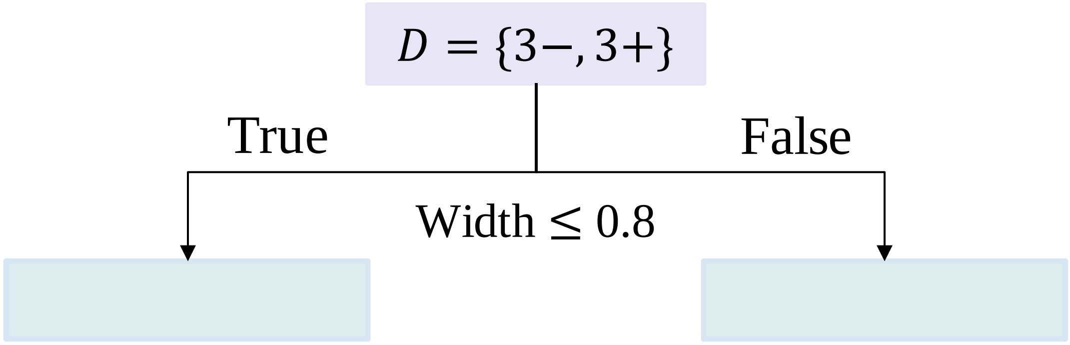
Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

Decision Tree Review

Decision Tree for Classification

$$Gini(D) = \frac{n_1}{n} Gini(D_1) + \frac{n_2}{n} Gini(D_2)$$

$$Gini(D_i) = 1 - \sum_{j=1}^{c} p_j^2$$



Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

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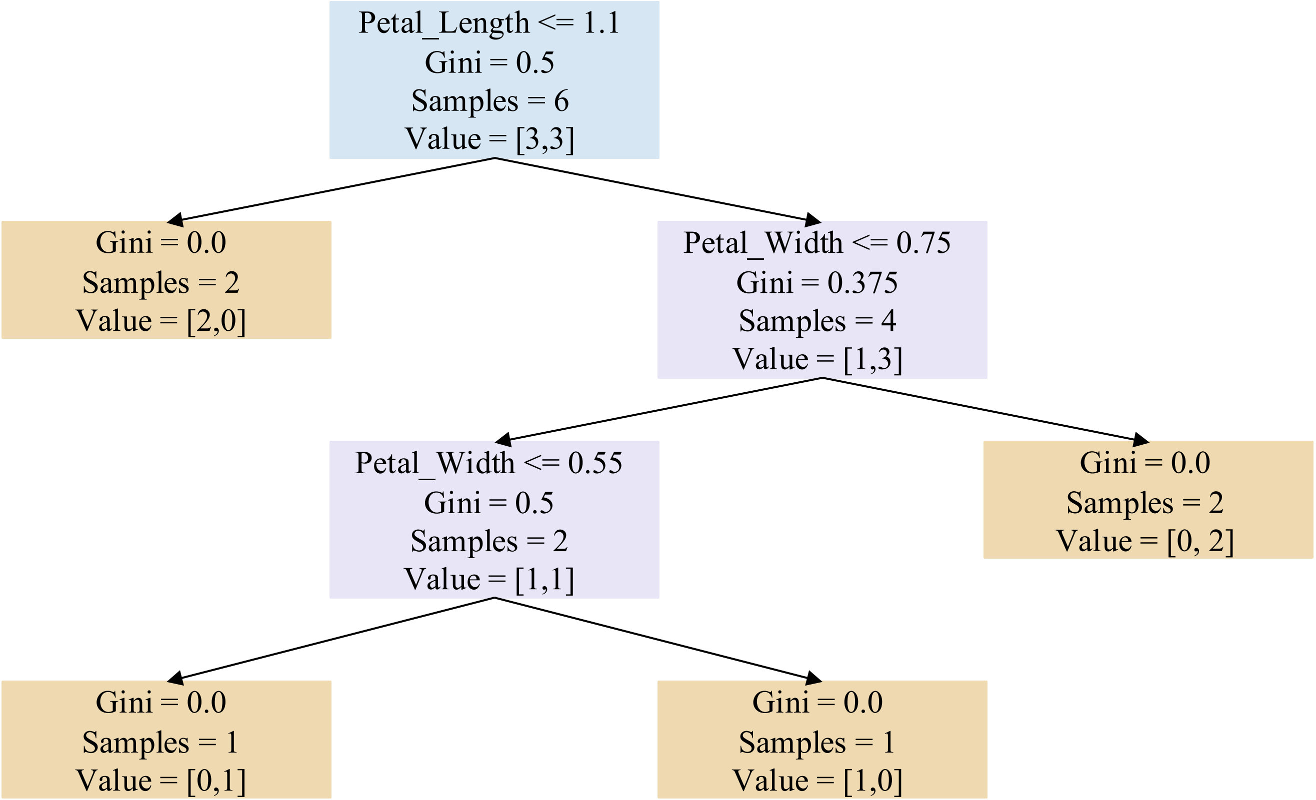
Decision Tree Review

Decision Tree for Classification

$$Gini(D) = \frac{n_1}{n} Gini(D_1) + \frac{n_2}{n} Gini(D_2)$$

$$Gini(D_i) = 1 - \sum_{j=1}^{c} p_j^2$$



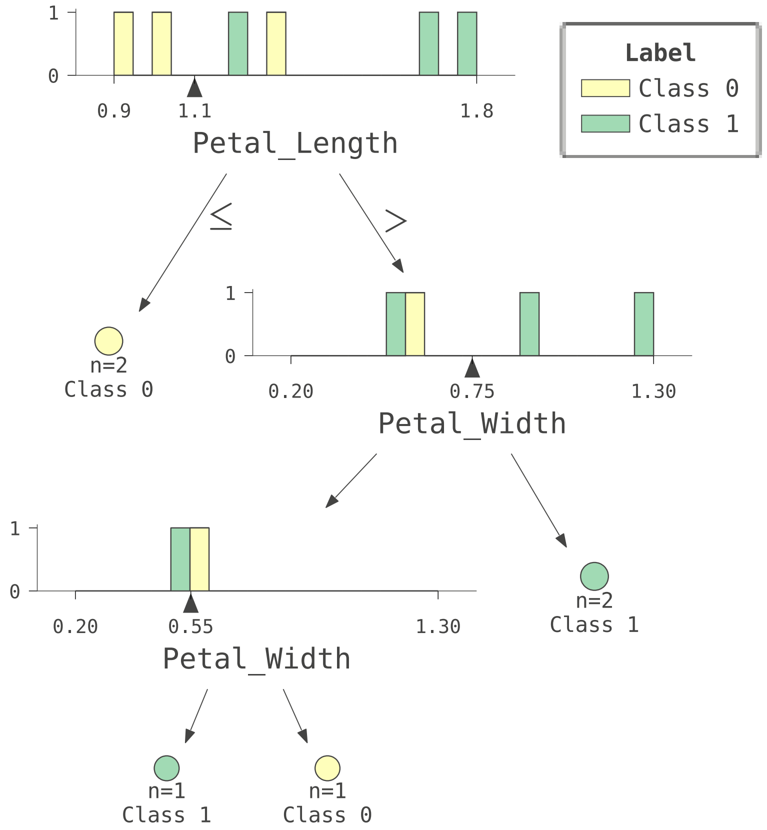
Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

Decision Tree Review

Decision Tree for Classification

$$Gini(D) = \frac{n_1}{n} Gini(D_1) + \frac{n_2}{n} Gini(D_2)$$

$$Gini(D_i) = 1 - \sum_{j=1}^{c} p_j^2$$



Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

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Decision Tree Review

Decision Tree for Classification

$$Gain(D) = 1 - Entropy(D)$$

$$Entropy(D) = \frac{n_1}{n} Entropy(D_1) + \frac{n_2}{n} Entropy(D_2)$$

$$Entropy(D_i) = -\sum_{j=1}^{c} p_j \log_2 p_j$$

$$D = \{3-, 3+\}$$

$$Entropy(D) = -\frac{3}{6}\log_2\frac{3}{3} - \frac{3}{6}\log_2\frac{3}{6} = 1$$

Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

Decision Tree Review

Decision Tree for Classification

$$Gain(D) = 1 - Entropy(D)$$

$$Entropy(D) = \frac{n_1}{n} Entropy(D_1) + \frac{n_2}{n} Entropy(D_2)$$

$$Entropy(D_i) = -\sum_{j=1}^{c} p_j \log_2 p_j$$

Numerical Feature	Ascending Ordering	Calculate mean	Determine Gini

Petal_Length
0.9
1
1.2
1.3
1.7
1.8

Mean	Entropy	Gain
0.95	$\text{Entropy}(Length \leq 0.95)$	$Gain(Length \leq 0.95)$
1.1	$\text{Entropy}(Length \leq 1.1)$	$Gain(Length \leq 1.1)$
1.25	$\text{Entropy}(Length \leq 1.25)$	$Gain(Length \leq 1.25)$
1.5	$\text{Entropy}(Length \leq 1.5)$	$Gain(Length \leq 1.5)$
1.75	$\text{Entropy}(Length \leq 1.75)$	$Gain(Length \leq 1.75)$

Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

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Decision Tree Review

Decision Tree for Classification

$$Gain(D) = 1 - Entropy(D)$$

$$Entropy(D) = \frac{n_1}{n} Entropy(D_1) + \frac{n_2}{n} Entropy(D_2)$$

$$Entropy(D_i) = -\sum_{j=1}^{c} p_j \log_2 p_j$$

$D = \{3-, 3+\}$

True | False

Length $\leq$ 1.5

$D_1 = \{3-, 1+\}$

$D_2 = \{0-, 2+\}$

$$Entropy(D_1) = -\frac{3}{4}\log_2\frac{3}{4} - \frac{1}{4}\log_2\frac{1}{4} = 0.81$$

$$Entropy(D_2) = -\frac{0}{2}\log_2\frac{0}{2} - \frac{2}{2}\log_2\frac{2}{2} = 0.0$$

$$Entropy(Length \leq 1.5) = \frac{4}{6} * 0.81 + \frac{2}{6} * 0.0 = 0.54$$

$$Gain(Length \leq 1.5) = 1 - 0.54 = 0.46$$

Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

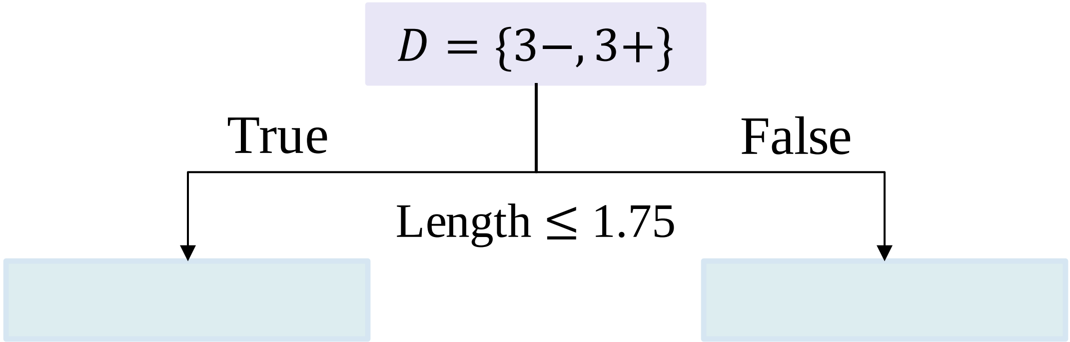
Decision Tree Review

Decision Tree for Classification

$$Gain(D) = 1 - Entropy(D)$$

$$Entropy(D) = \frac{n_1}{n} Entropy(D_1) + \frac{n_2}{n} Entropy(D_2)$$

$$Entropy(D_i) = -\sum_{j=1}^{c} p_j \log_2 p_j$$



Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

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Decision Tree Review

Decision Tree for Classification

$$Gain(D) = 1 - Entropy(D)$$

$$Entropy(D) = \frac{n_1}{n} Entropy(D_1) + \frac{n_2}{n} Entropy(D_2)$$

$$Entropy(D_i) = -\sum_{j=1}^{c} p_j \log_2 p_j$$

Numerical Feature	Ascending Ordering	Calculate mean	Determine Gini

Petal_Width
0.2
0.5
0.6
0.7
0.9
1.3

Threshold	Entropy	Gain
0.35	$\text{Entropy}(Width \leq 0.35)$	$Gain(Width \leq 0.35)$
0.55	$\text{Entropy}(Width \leq 0.55)$	$Gain(Width \leq 0.55)$
0.65	$\text{Entropy}(Width \leq 0.65)$	$Gain(Width \leq 0.65)$
0.8	$\text{Entropy}(Width \leq 0.8)$	$Gain(Width \leq 0.8)$
1.1	$\text{Entropy}(Width \leq 1.1)$	$Gain(Width \leq 1.1)$

Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

Decision Tree Review

Decision Tree for Classification

$$Gain(D) = 1 - Entropy(D)$$

$$Entropy(D) = \frac{n_1}{n} Entropy(D_1) + \frac{n_2}{n} Entropy(D_2)$$

$$Entropy(D_i) = -\sum_{j=1}^{c} p_j \log_2 p_j$$

$D = \{3-, 3+\}$

Width $\leq$ 0.8

True: $D_1 = \{3-, 1+\}$

False: $D_2 = \{0-, 2+\}$

$$Entropy(D_1) = -\frac{3}{4}\log_2\frac{3}{4} - \frac{1}{4}\log_2\frac{1}{4} = 0.81$$

$$Entropy(D_2) = -\frac{0}{2}\log_2\frac{0}{2} - \frac{2}{2}\log_2\frac{2}{2} = 0.0$$

$$Entropy(Width \leq 0.8) = \frac{4}{6} * 0.81 + \frac{2}{6} * 0.0 = 0.54$$

$$Gain(Width \leq 0.8) = 1 - 0.54 = 0.46$$

Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

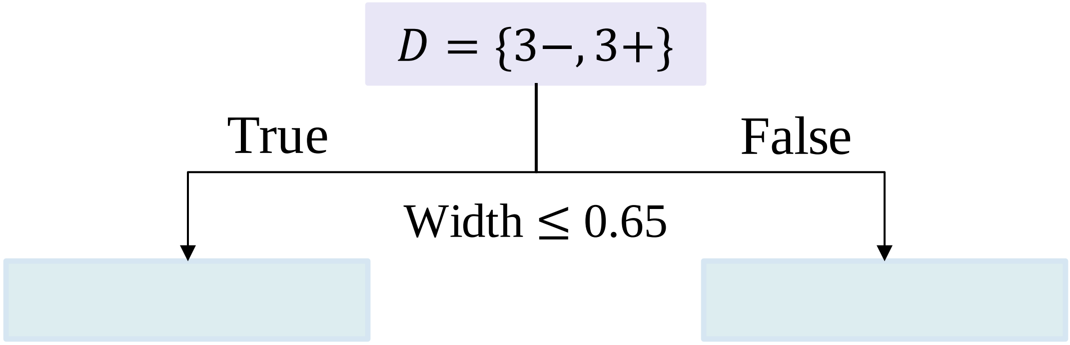
Decision Tree Review

Decision Tree for Classification

$$Gain(D) = 1 - Entropy(D)$$

$$Entropy(D) = \frac{n_1}{n} Entropy(D_1) + \frac{n_2}{n} Entropy(D_2)$$

$$Entropy(D_i) = -\sum_{j=1}^{c} p_j \log_2 p_j$$



Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

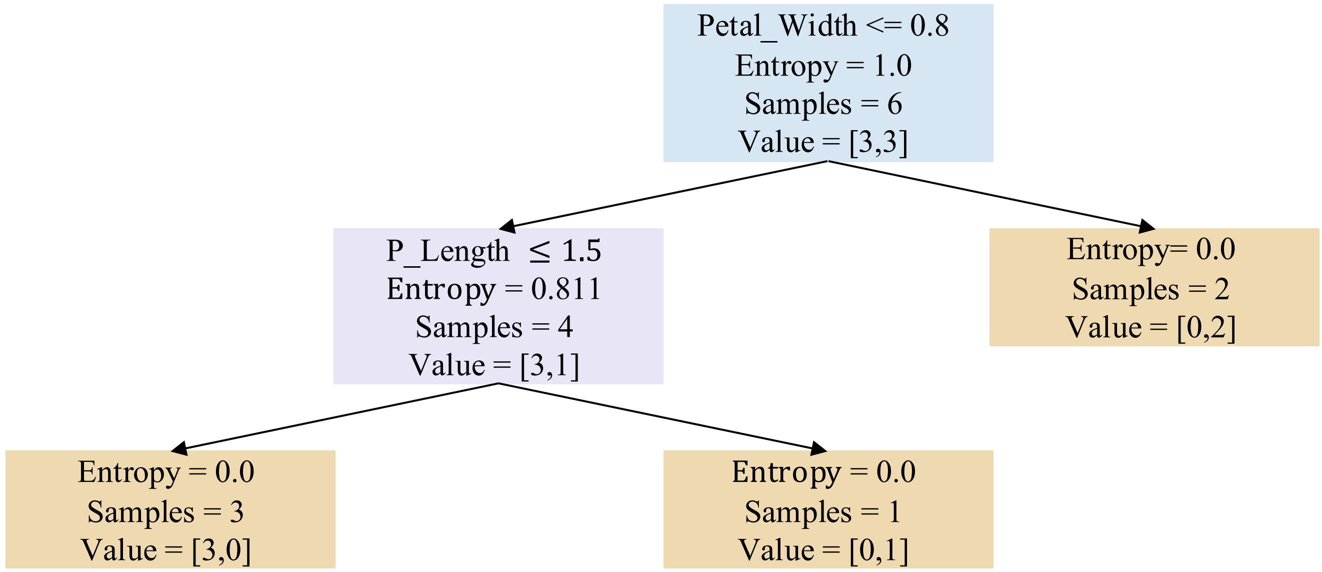
Decision Tree Review

Decision Tree for Classification

$$Gain(D) = 1 - Entropy(D)$$

$$Entropy(D) = \frac{n_1}{n} Entropy(D_1) + \frac{n_2}{n} Entropy(D_2)$$

$$Entropy(D_i) = -\sum_{j=1}^{c} p_j \log_2 p_j$$



Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

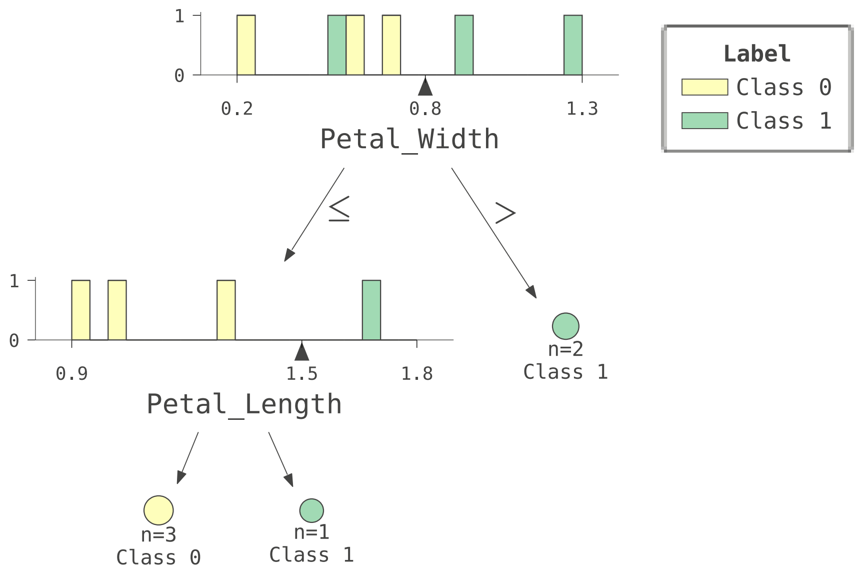
Decision Tree Review

Decision Tree for Classification

$$Gain(D) = 1 - Entropy(D)$$

$$Entropy(D) = \frac{n_1}{n} Entropy(D_1) + \frac{n_2}{n} Entropy(D_2)$$

$$Entropy(D_i) = -\sum_{j=1}^{c} p_j \log_2 p_j$$



Petal_Length	Petal_Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

Decision Tree Review

Decision Tree for Regression

$$SSE(D) = SSE(D_1) + SSE(D_2)$$
$$MSE(D) = MSE(D_1) + MS(D_2)$$

$$SSE(D_i) = \sum_{j=1}^{n_i} (x_j - \bar{x}_i)^2$$

$$MSE(D_i) = \frac{1}{n_i} \sum_{j=1}^{n_i} (x_j - \bar{x}_i)^2$$

Experience
1.5
2.5
4.0
5.5

2.0
3.25
4.75

$SSE(\text{Experience} \leq 2.0)$ | $MSE(\text{Experience} \leq 2.0)$

$SSE(\text{Experience} \leq 3.25)$ | $MSE(Experience \leq 3.25)$

$SSE(\text{Experience} \leq 4.75)$ | $MSE(Experience \leq 4.75)$

Experience	Salary
1.5	0
2.5	0
4.0	55
5.5	83

Decision Tree Review

Decision Tree for Regression

$$SSE(D) = SSE(D_1) + SSE(D_2)$$
$$MSE(D) = MSE(D_1) + MS(D_2)$$

$$SSE(D_i) = \sum_{j=1}^{n_i} (x_j - \bar{x}_i)^2$$

$$MSE(D_i) = \frac{1}{n_i} \sum_{j=1}^{n_i} (x_j - \bar{x}_i)^2$$

$$D = \{0, 0, 55, 83\}$$

$$mean(D) = 34.5$$

$$SSE(D_1) = (0 - 34.5)^2 + (0 - 34.5)^2 + (55 - 34.5)^2 + (83 - 34.5)^2 = 5153$$

$$MSE(D_1) = \frac{(0 - 34.5)^2 + (0 - 34.5)^2 + (55 - 34.5)^2 + (83 - 34.5)^2}{4} = 1288.25$$

Experience	Salary
1.5	0
2.5	0
4.0	55
5.5	83

AI VIET NAM
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Decision Tree Review

Decision Tree for Regression

$$SSE(D) = SSE(D_1) + SSE(D_2)$$
$$MSE(D) = MSE(D_1) + MS(D_2)$$

$$SSE(D_i) = \sum_{j=1}^{n_i} (x_j - \bar{x}_i)^2$$

$$MSE(D_i) = \frac{1}{n_i} \sum_{j=1}^{n_i} (x_j - \bar{x}_i)^2$$

$D = \{0, 0, 55, 83\}$

True / False

$SSE(Experience \leq 2.0)$

$D_1 = \{0\}$

$mean(D_1) = 0$

$D_2 = \{0, 55, 83\}$

$mean(D_2) = 46$

Experience	Salary
1.5	0
2.5	0
4.0	55
5.5	83

$$SSE(D_1) = (0 - 0)^2 = 0$$

$$SSE(D_2) = (0 - 46)^2 + (55 - 46)^2 + (83 - 46)^2 = 1450$$

$$SSE(Experience \leq 2.0) = 1450$$

Decision Tree Review

Decision Tree for Regression

$$SSE(D) = SSE(D_1) + SSE(D_2)$$
$$MSE(D) = MSE(D_1) + MS(D_2)$$

$$SSE(D_i) = \sum_{j=1}^{n_i} (x_j - \bar{x}_i)^2$$

$$MSE(D_i) = \frac{1}{n_i} \sum_{j=1}^{n_i} (x_j - \bar{x}_i)^2$$

$D = \{0, 0, 55, 83\}$

$MSE(Experience \leq 2.0)$

True: $D_1 = \{0\}$, $mean(D_1) = 0$

False: $D_2 = \{0, 55, 83\}$, $mean(D_2) = 46$

Experience	Salary
1.5	0
2.5	0
4.0	55
5.5	83

$$MSE(D_1) = \frac{(0-0)^2}{1} = 0$$

$$MSE(D_2) = \frac{(0-46)^2 + (55-46)^2 + (83-46)^2}{3} = 483$$

$$MSE(Experience \leq 2.0) = 483$$

AI VIET NAM
@aivietnam.edu.vn

Decision Tree Review

! Decision Tree for Regression

$$SSE(D) = SSE(D_1) + SSE(D_2)$$
$$MSE(D) = MSE(D_1) + MS(D_2)$$

$$SSE(D_i) = \sum_{j=1}^{n_i} (x_j - \bar{x}_i)^2$$

$$MSE(D_i) = \frac{1}{n_i} \sum_{j=1}^{n_i} (x_j - \bar{x}_i)^2$$

$D = \{0, 0, 55, 83\}$

True | False

$MSE(Experience \leq 3.25)$

True | False

$MSE(Experience \leq 4.75)$

Experience	Salary
1.5	0
2.5	0
4.0	55
5.5	83

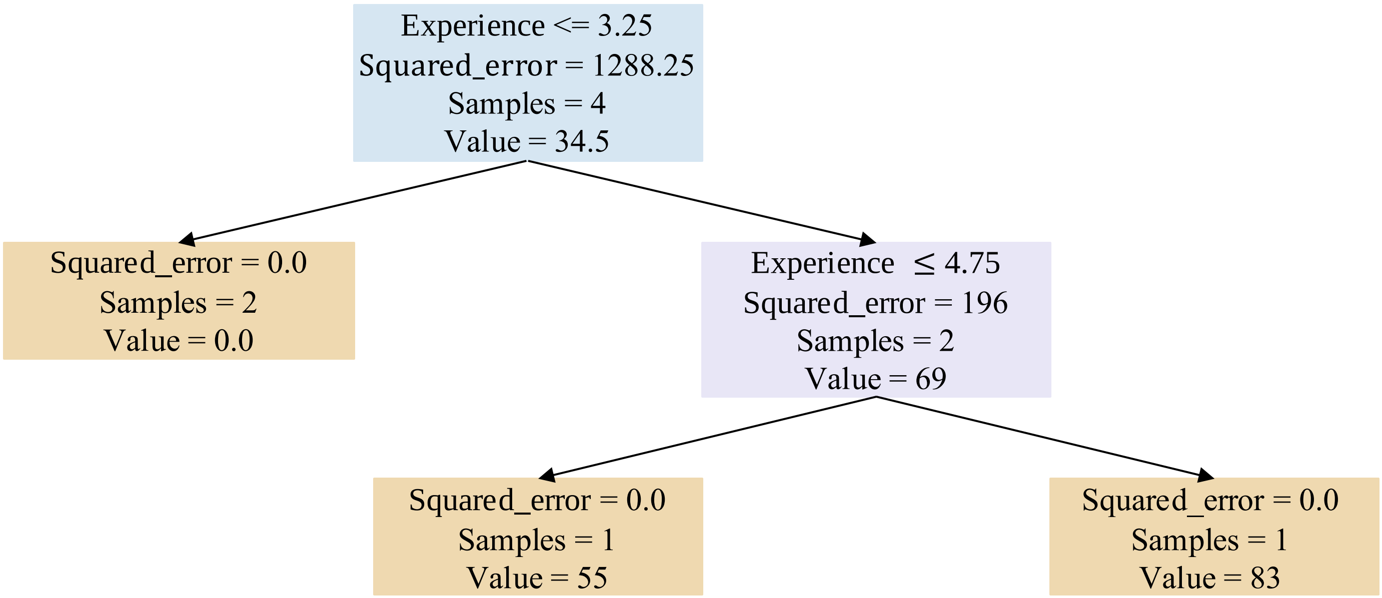
Decision Tree Review

Decision Tree for Regression

$$SSE(D) = SSE(D_1) + SSE(D_2)$$
$$MSE(D) = MSE(D_1) + MS(D_2)$$

$$SSE(D_i) = \sum_{j=1}^{n_i} (x_j - \bar{x}_i)^2$$

$$MSE(D_i) = \frac{1}{n_i} \sum_{j=1}^{n_i} (x_j - \bar{x}_i)^2$$



Experience	Salary
1.5	0
2.5	0
4.0	55
5.5	83

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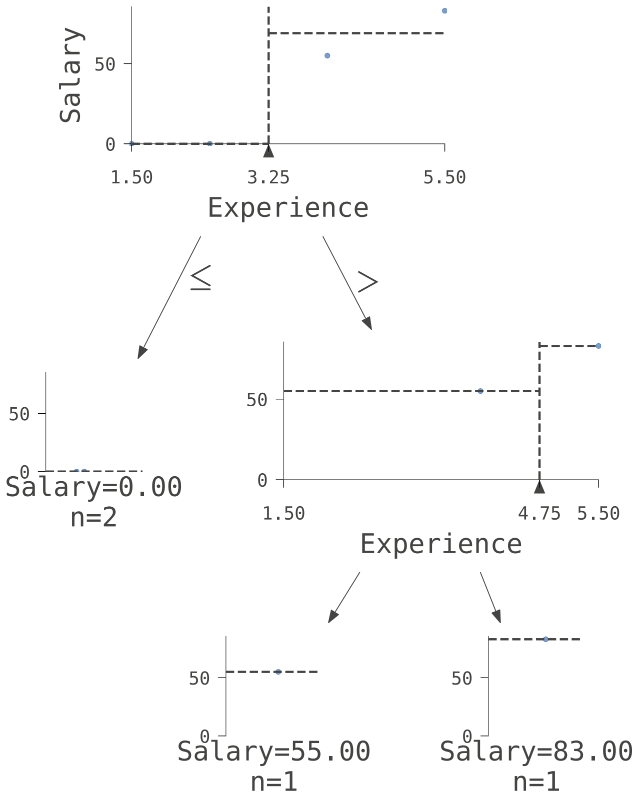
Decision Tree for Regression

$$SSE(D) = SSE(D_1) + SSE(D_2)$$
$$MSE(D) = MSE(D_1) + MS(D_2)$$

$$SSE(D_i) = \sum_{j=1}^{n_i} (x_j - \bar{x}_i)^2$$

$$MSE(D_i) = \frac{1}{n_i}\sum_{j=1}^{n_i} (x_j - \bar{x}_i)^2$$



Experience	Salary
1.5	0
2.5	0
4.0	55
5.5	83

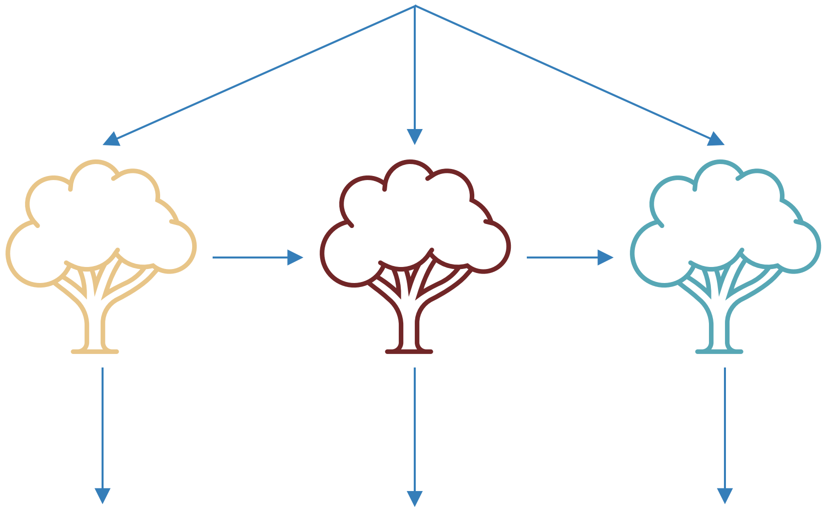
Outline

SECTION 1

Decision Tree Review

SECTION 2

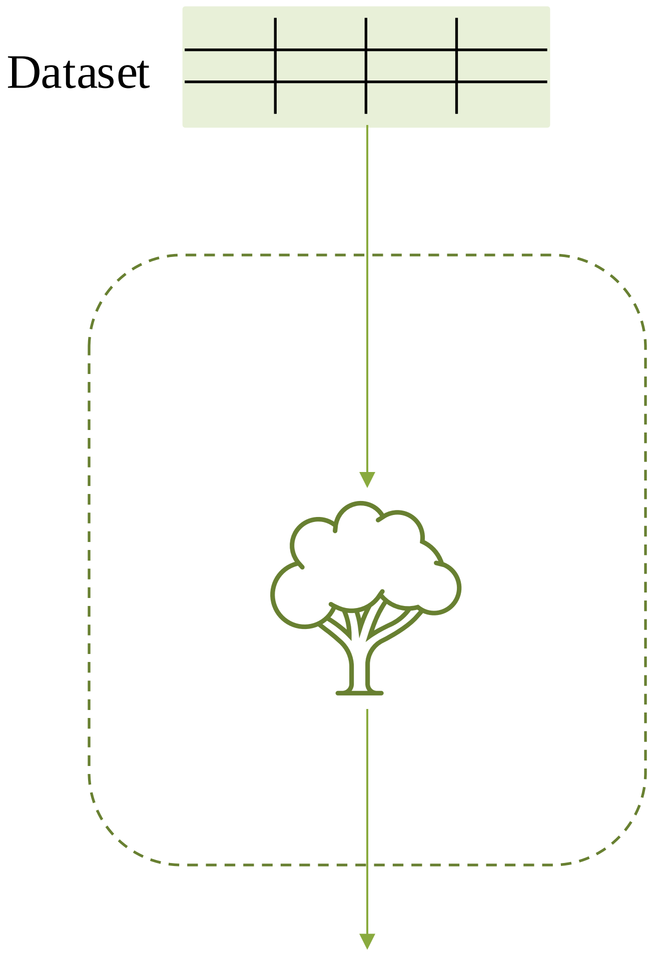
Random Forest



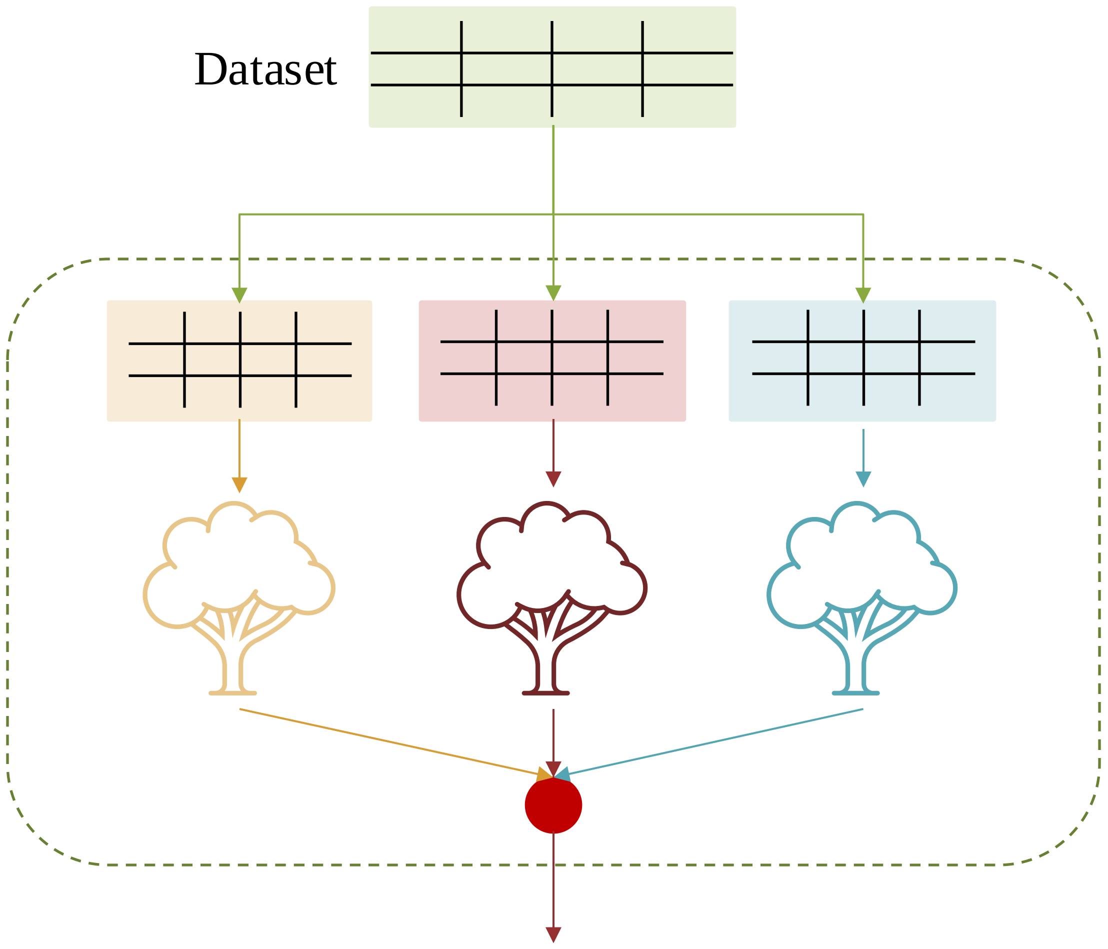
Random Forest

From Decision Tree to Random Forest

Decision Tree



Random Forest

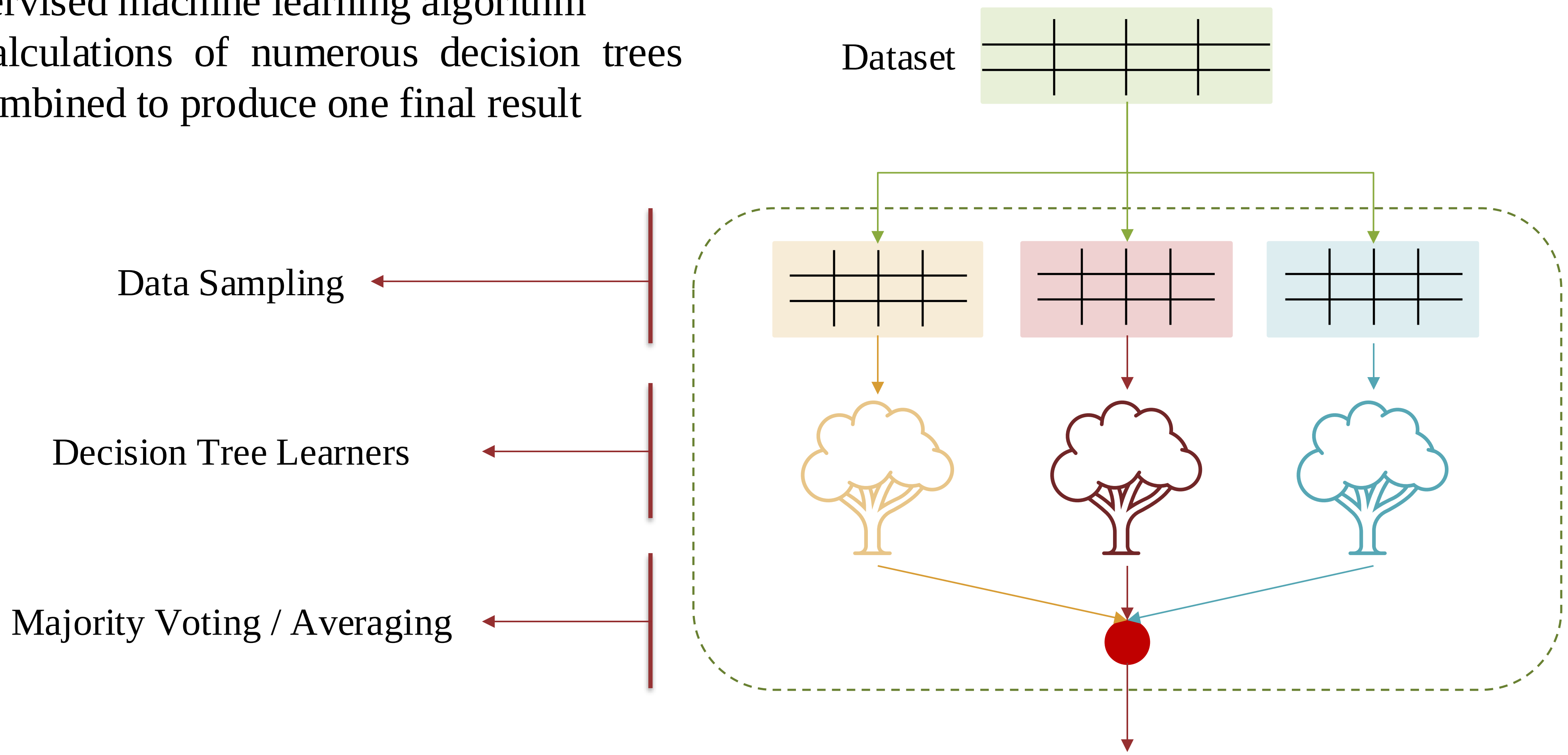


Random Forest

Random Forest

A random forest

- a supervised machine learning algorithm
- the calculations of numerous decision trees are combined to produce one final result



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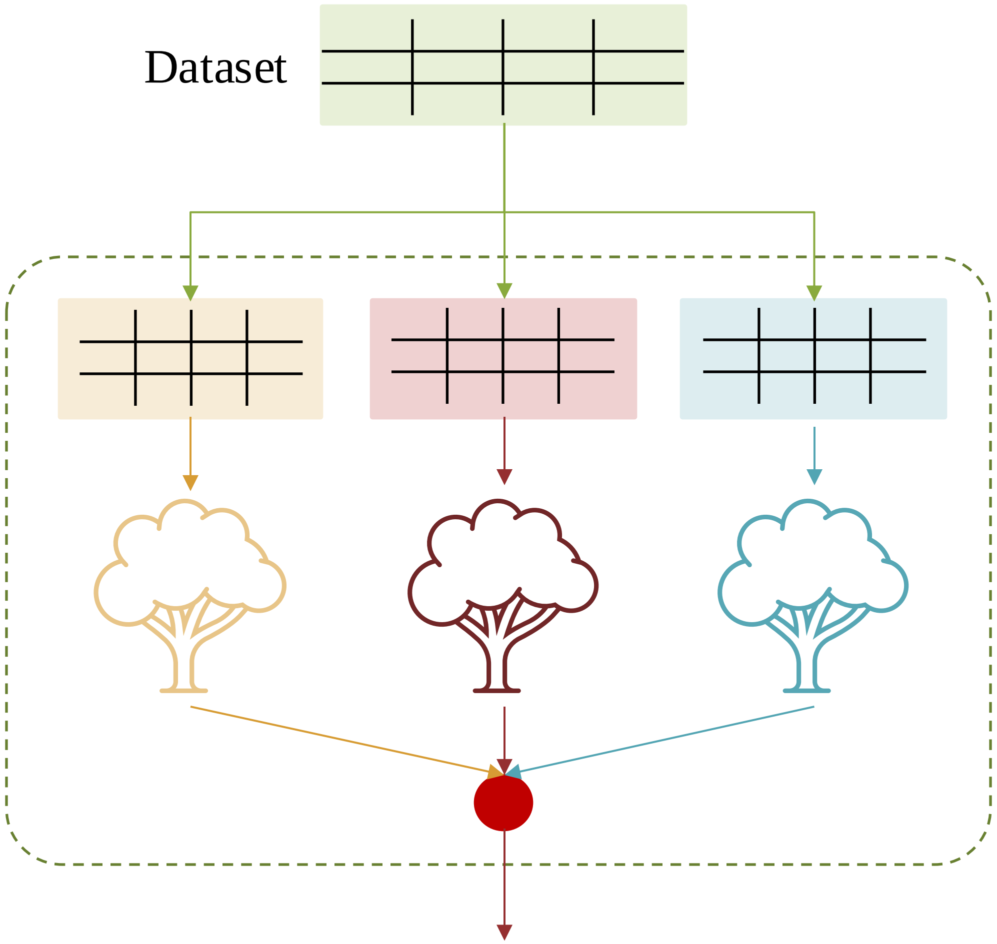
@aivietnam.edu.vn

Random Forest

Data Sampling



Feature = 1

Randomly sample with replacement

Length	Width	Label
1	0.2	0
1.3	0.6	0
0.9	0.7	0
1.7	0.5	1
1.8	0.9	1
1.2	1.3	1

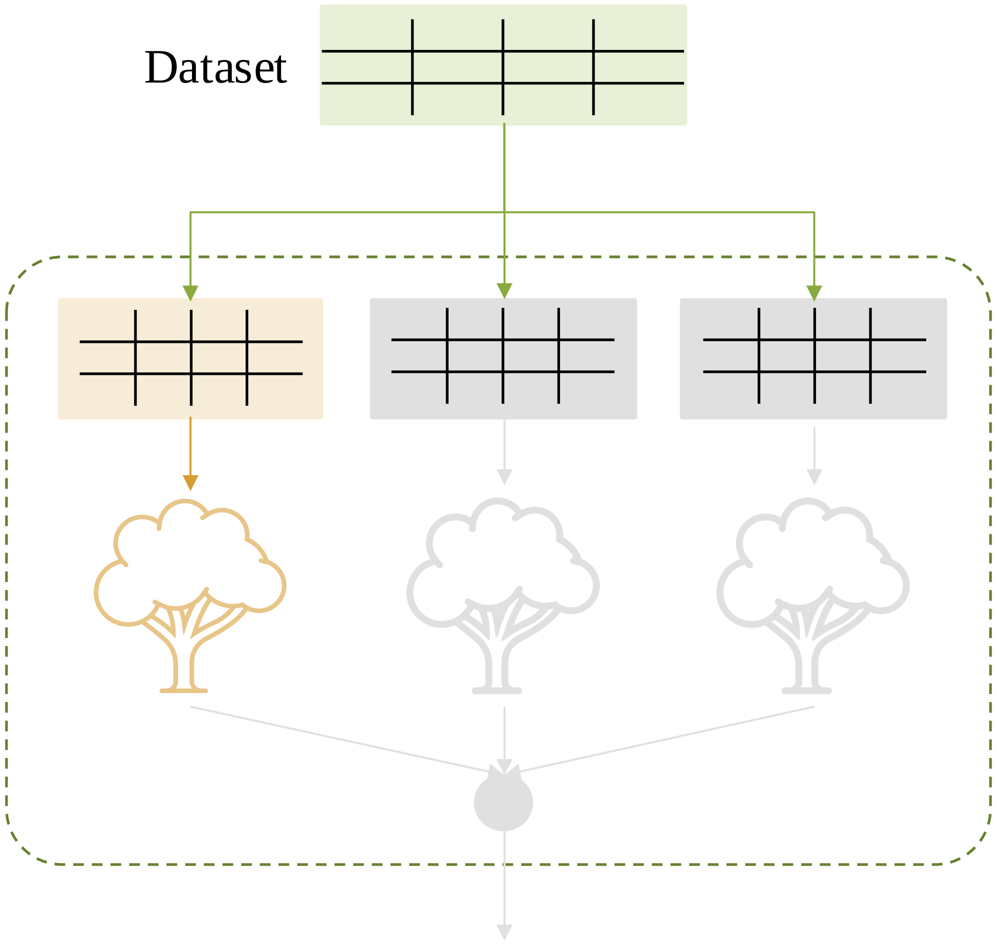
Length	Label
1	0
1.3	0
1	0
1.8	1
1.8	1
1.2	1

Width	Label
0.6	0
0.6	0
0.7	0
0.7	0
0.9	1
1.3	1

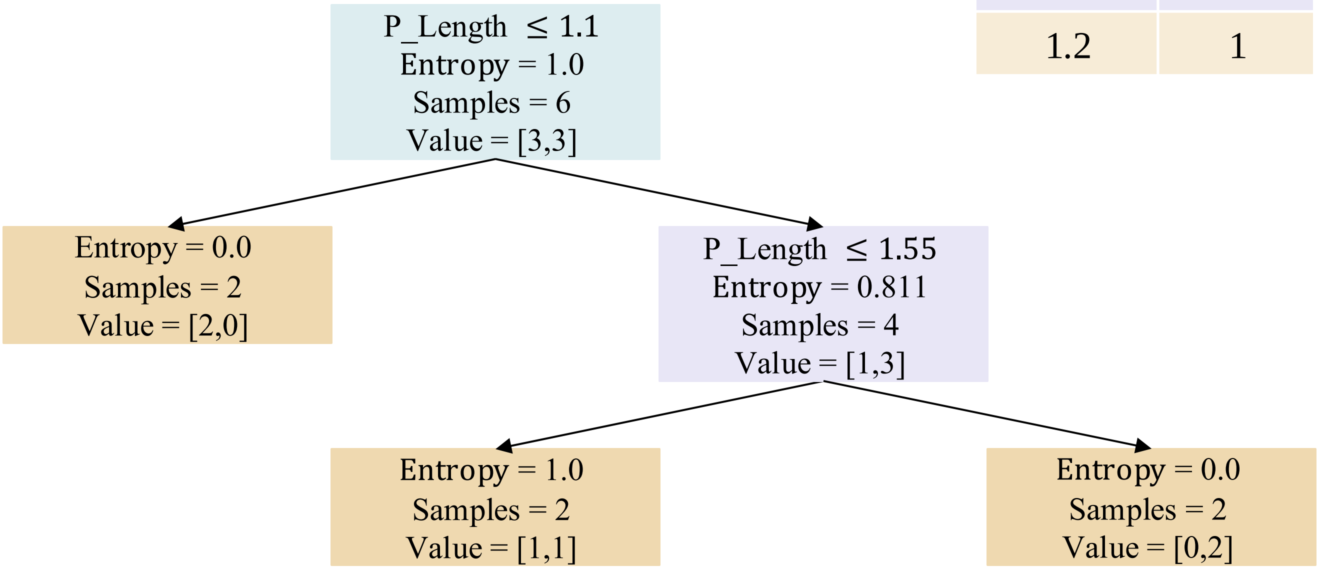
Length	Label
1	0
1.3	0
1.2	1
1.8	1
1.8	1
1.2	1

Random Forest

Decision Tree Learners

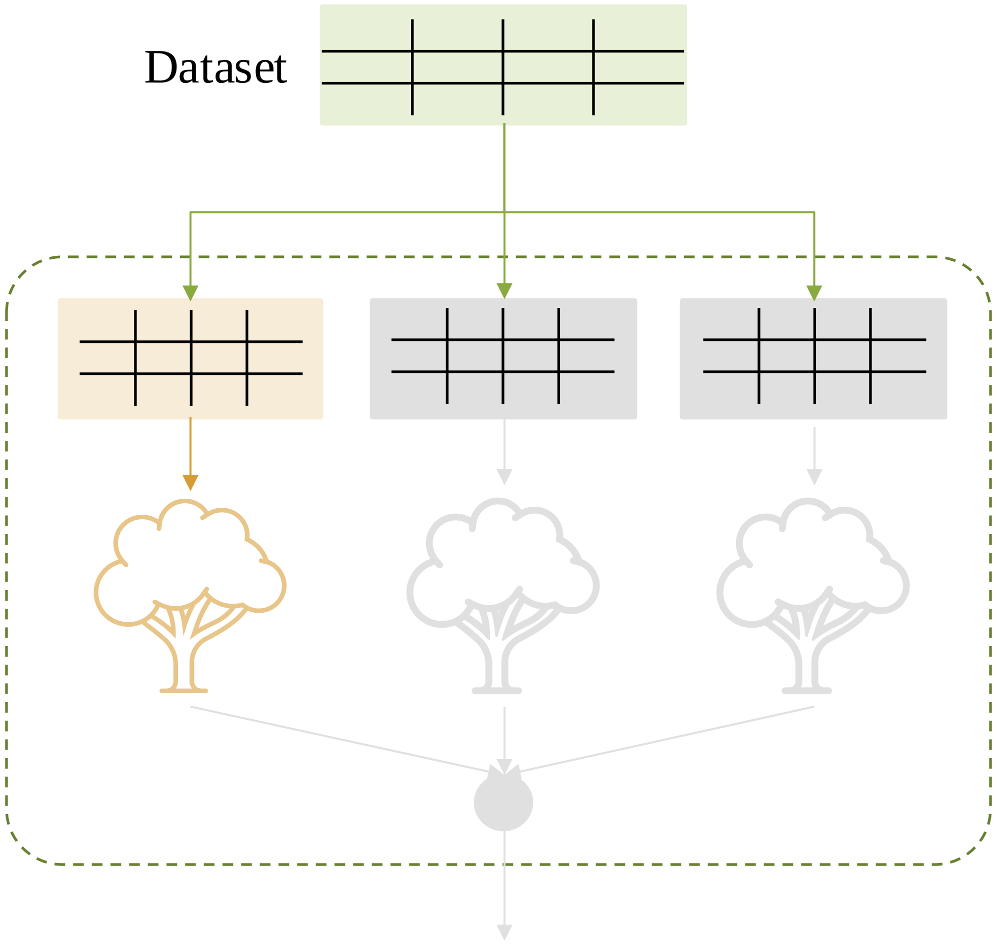


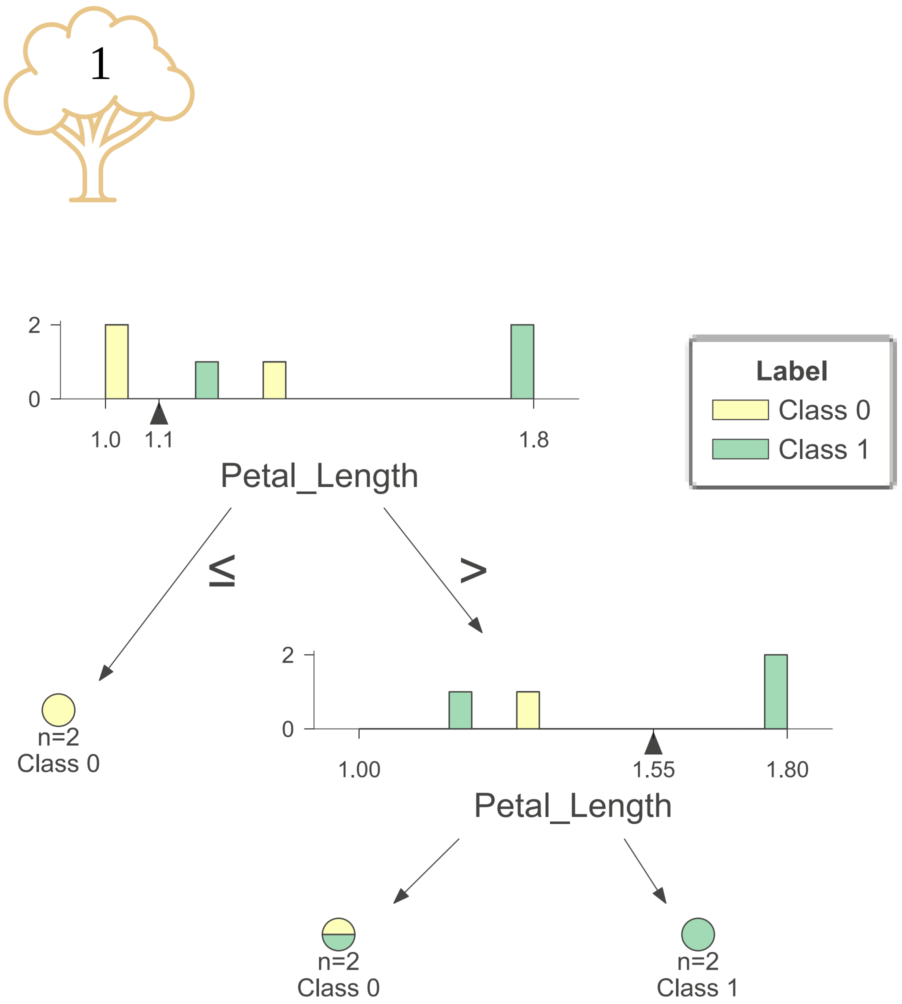
Length	Label
1	0
1.3	0
1	0
1.8	1
1.8	1
1.2	1



Random Forest

Decision Tree Learners

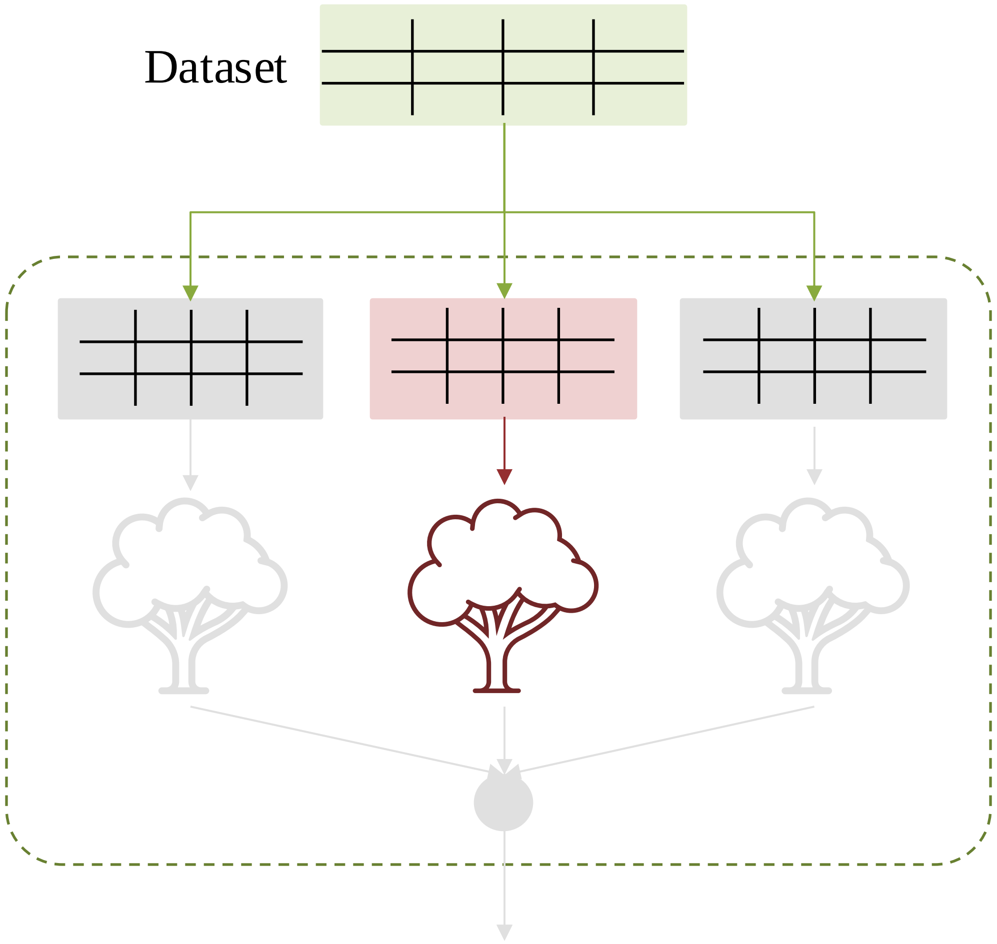


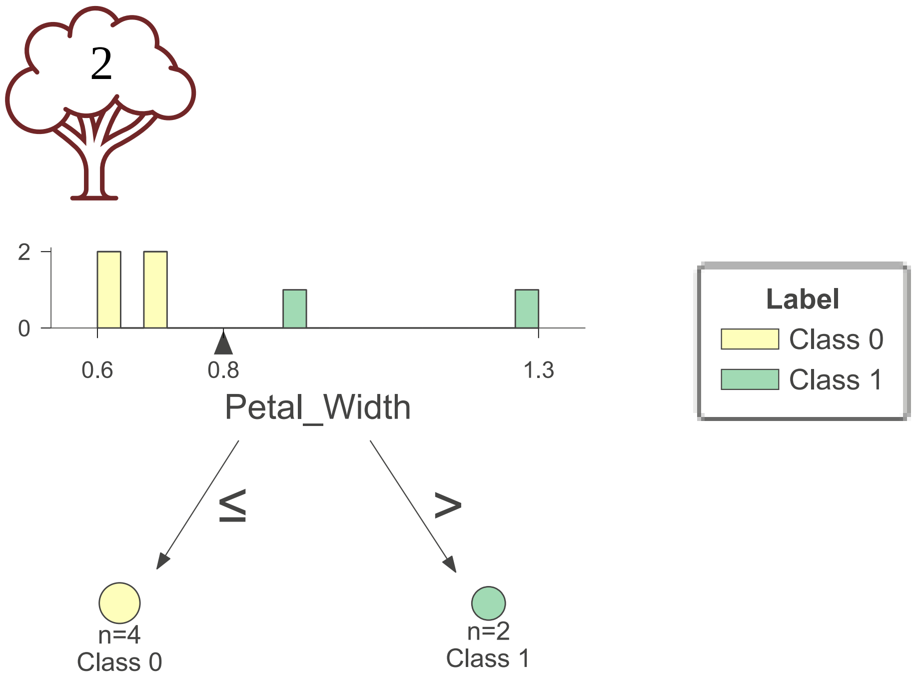


Length	Label
1	0
1.3	0
1	0
1.8	1
1.8	1
1.2	1

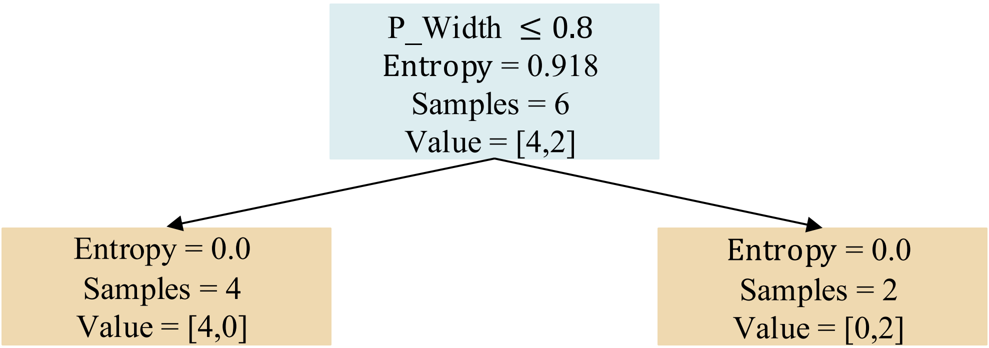
Random Forest

Decision Tree Learners





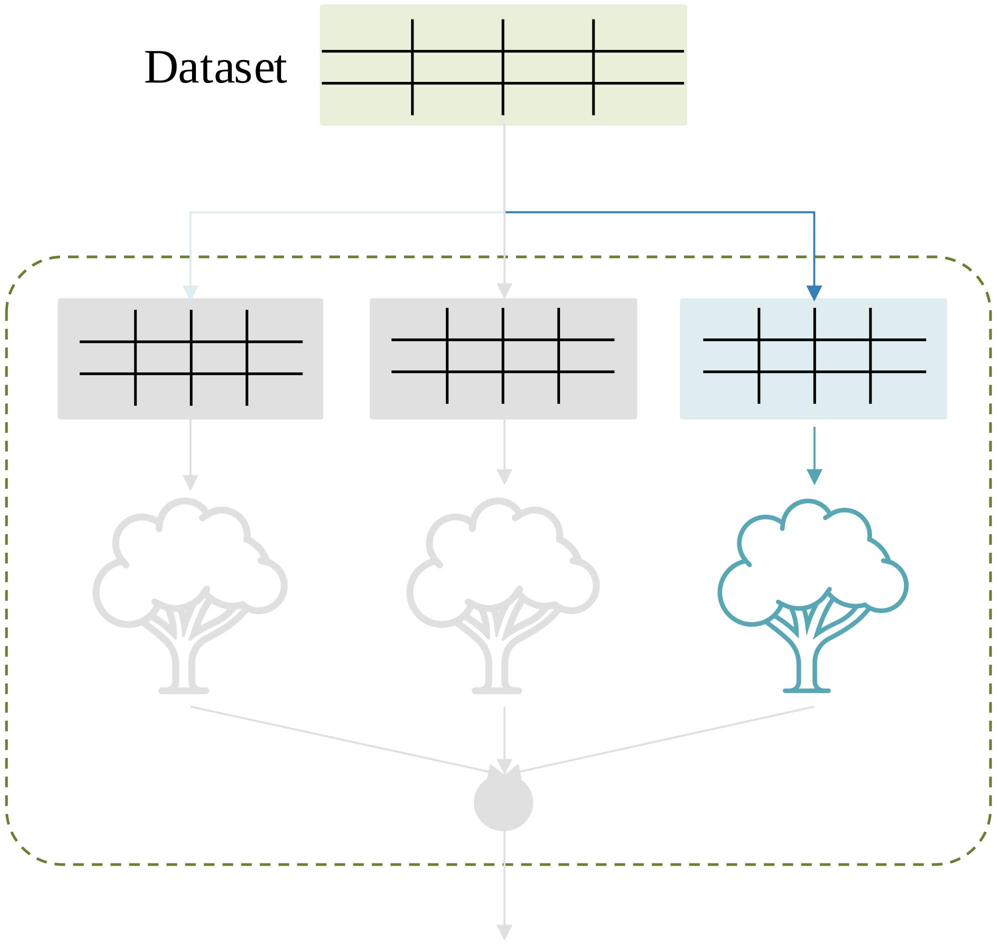
Width	Label
0.6	0
0.6	0
0.7	0
0.7	0
0.9	1
1.3	1

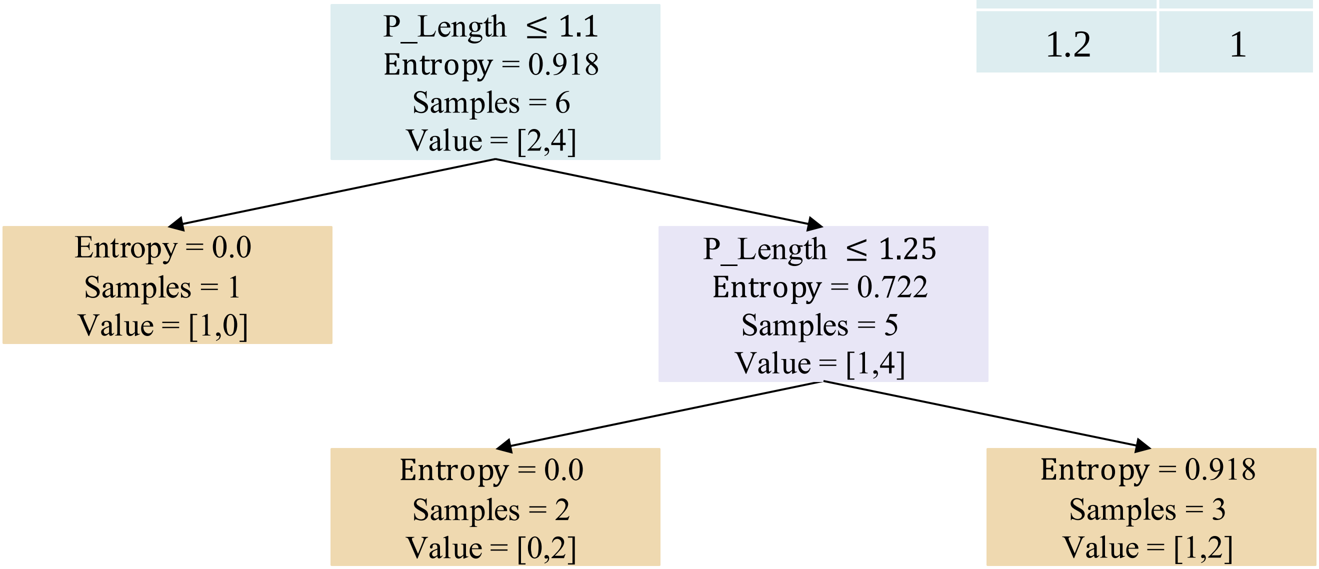


Random Forest

Decision Tree Learners

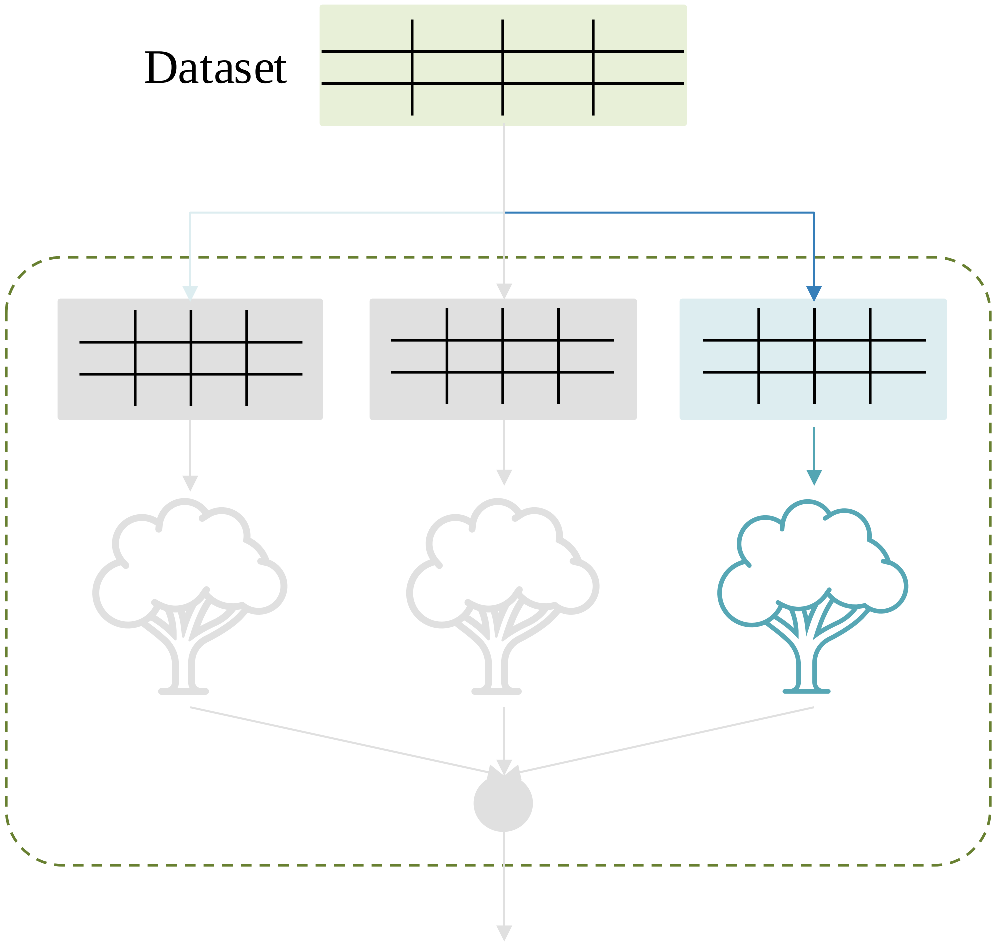
Length	Label
1	0
1.3	0
1.2	1
1.8	1
1.8	1
1.2	1

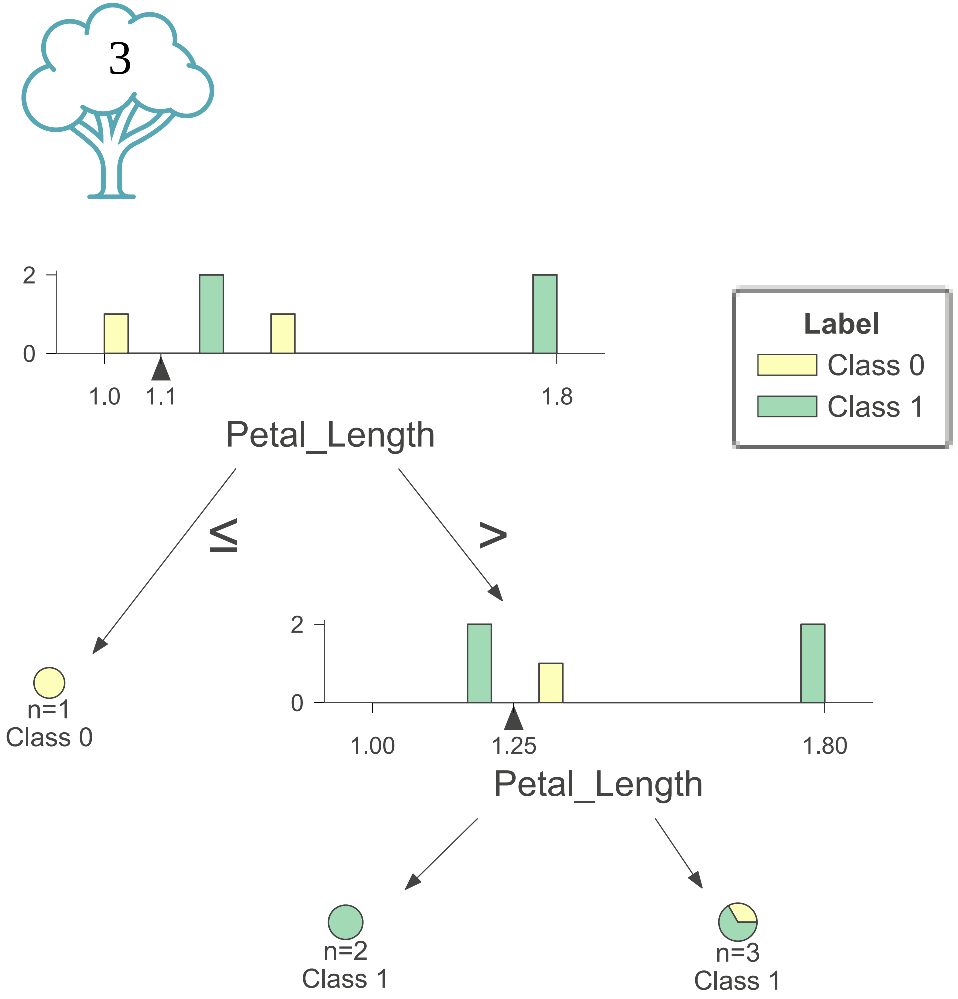




Random Forest

Decision Tree Learners



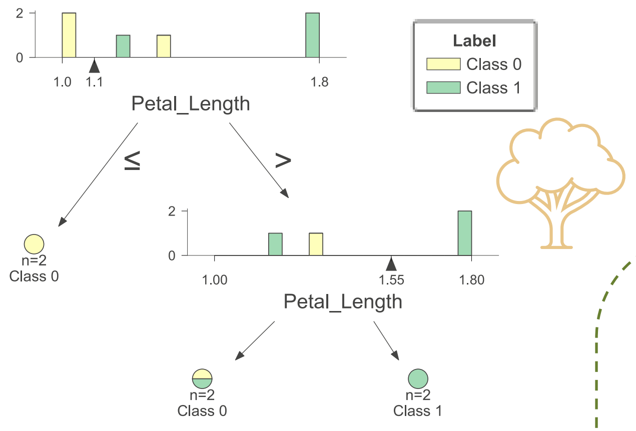


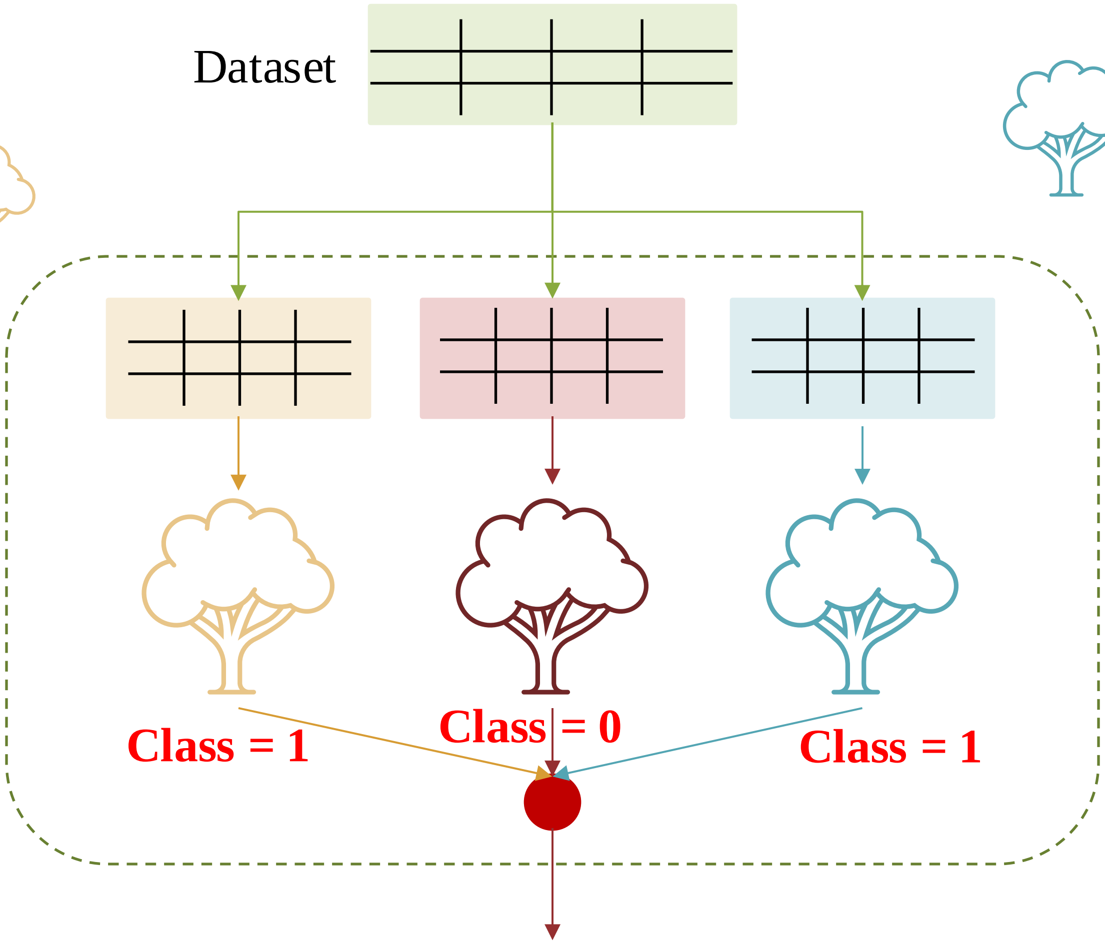
Length	Label
1	0
1.3	0
1.2	1
1.8	1
1.8	1
1.2	1

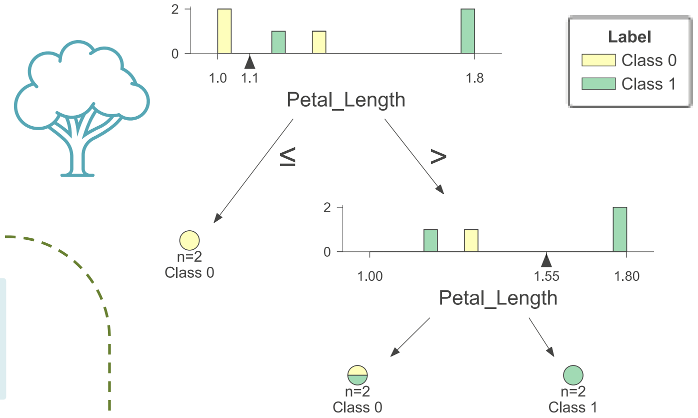
AI VIET NAM
@aivietnam.edu.vn

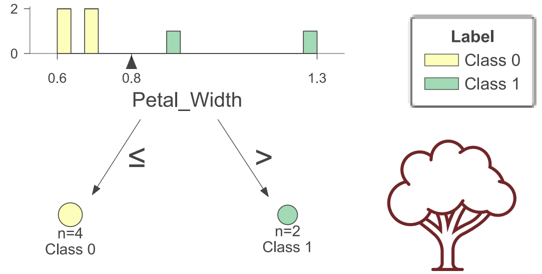
Random Forest

Majority Voting for Classification







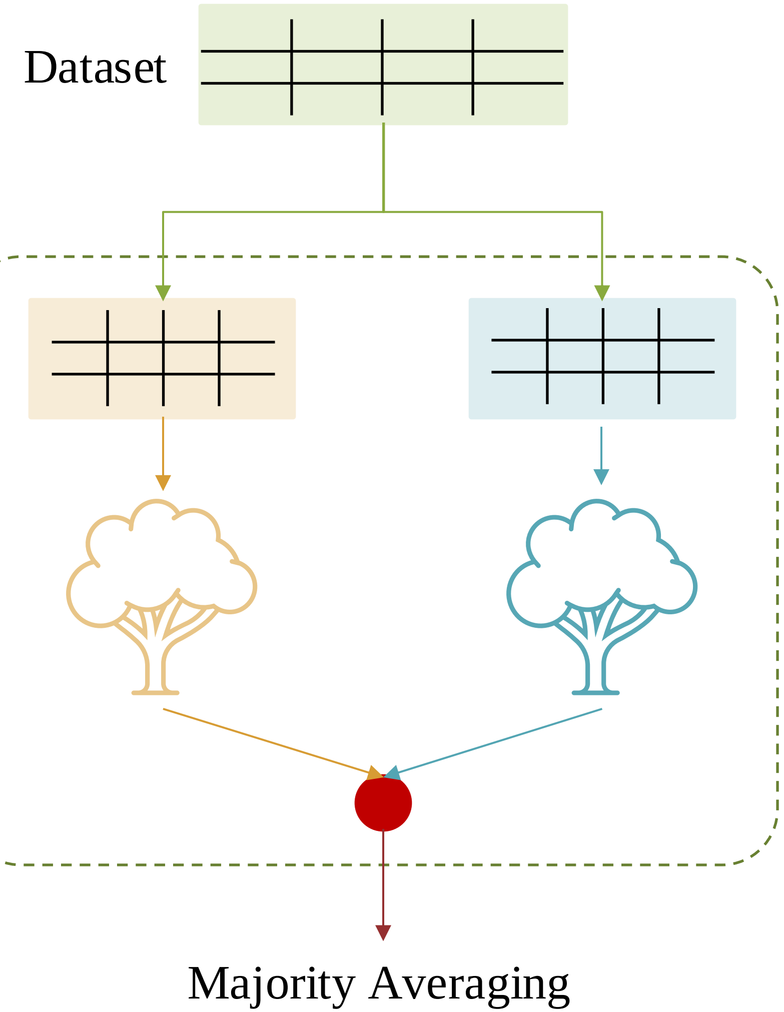


Test sample:
Petal_Length = 1.6
Petal_Width = 0.8

Majority Voting **Class = 1**

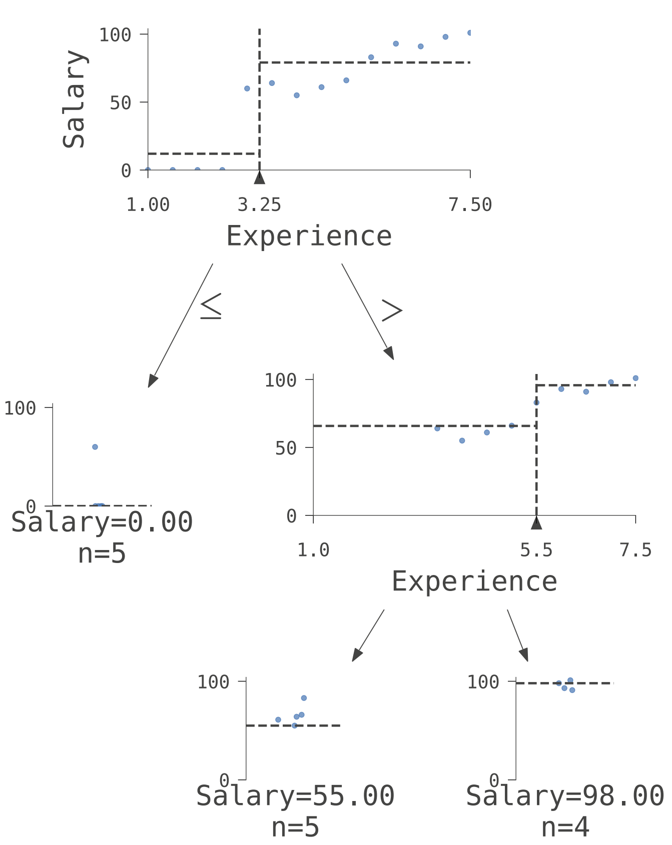
Random Forest

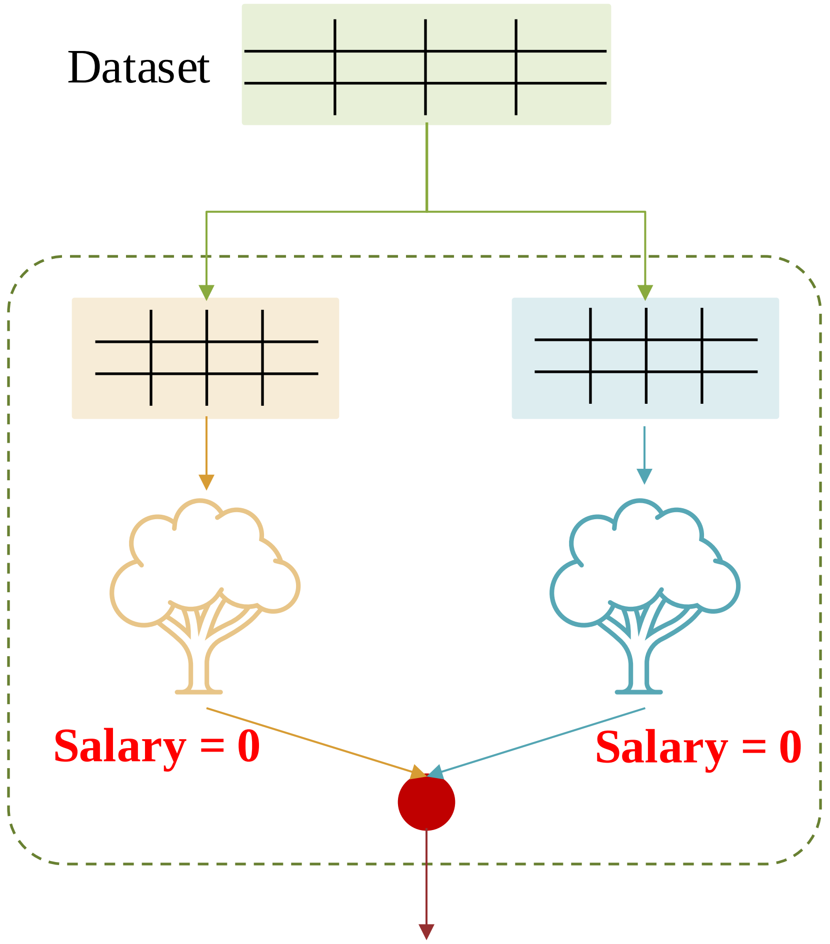
Random Forest for Regression

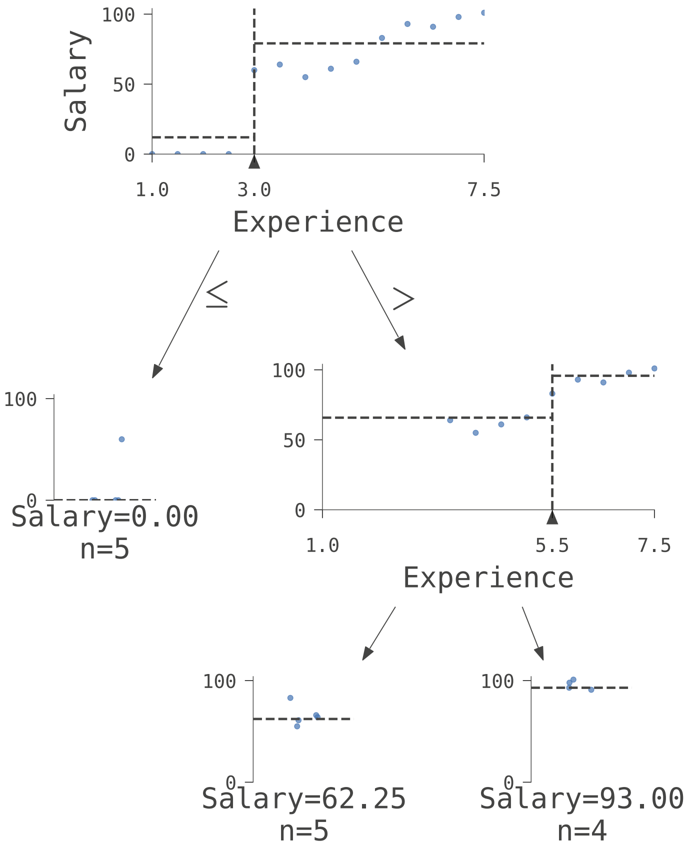


Random Forest

Majority Averaging for Regression







Test sample:
Experience = 3

Majority Averaging **Salary = (0+0)/2=0**

QUIZ TIME

AI VIET NAM
@aivietnam.edu.vn

Random Forest

Random Forest for Classification

```python
import pandas as pd
import numpy as np
from sklearn.ensemble import RandomForestClassifier

# Load data
df = pd.read_csv('iris_2D.csv')

# Get data
x_data = df[['Petal_Length', 'Petal_Width']].to_numpy()
x_data = x_data.reshape(6, 2)
y_data = df['Label'].to_numpy(dtype=np.uint8)
```

```python
# Define model
rf_classifier = RandomForestClassifier(
    n_estimators=3,
    max_features=1,
    max_depth=1,
    criterion='entropy',
    max_samples=6
)

# Train model
rf_classifier.fit(x_data, y_data)

# Predict
x_test = np.array([[2.7, 0.8]])
y_predicted = rf_classifier.predict(x_test)
y_predicted
```

Random Forest

Random Forest for Regression

```python
import pandas as pd
from sklearn.ensemble import RandomForestRegressor

# Load data
df = pd.read_csv('Salary_Data.csv')

# Get data
x_data = df.iloc[:, :-1]
y_data = df.iloc[:, -1]

# Define model
rf_regressor = RandomForestRegressor(
    n_estimators=2,
    max_depth=2,
    max_samples=7
)

# Train model
rf_regressor.fit(x_data, y_data)

# Predict
x_test = x_data[:2]
y_pred = rf_regressor.predict(x_test)
y_pred
```

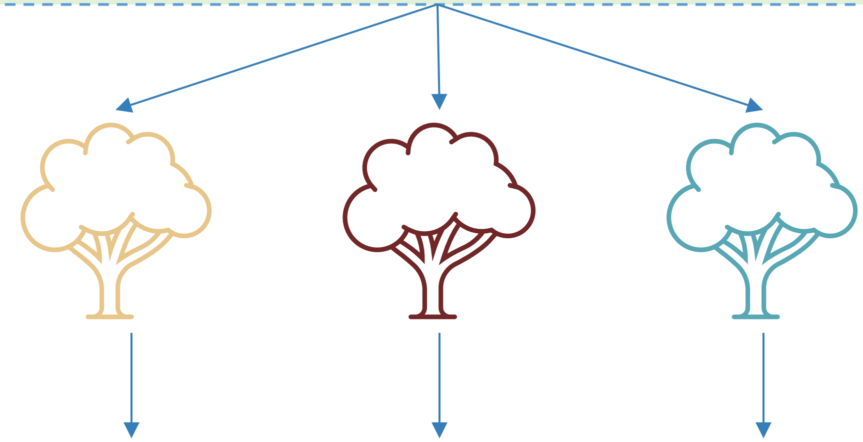
Summary

Decision Tree Review

- ❖ Decision Tree
- ❖ Decision Tree for Classification
- ❖ Decision Tree for Regression
- ❖ IRIS Classification
- ❖ Salary Prediction

Random Forest

- ❖ Decision Tree
- ❖ Random Forest
    - Bootstrap Sample
    - Majority Voting / Averaging
- ❖ IRIS Classification
- ❖ Salary Prediction



Thanks!

Any questions?