**CS483 - Fundamentals of Artificial Intelligence**
**Homework Assignment #4**
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1. Re-calculate the entropy for the feature selection in the example of file "*Gini Impurity Cal in Decision Tree*" rather than Gini impurity method. And then, compare the results from two different criteria

   *Hint: taking the reference at the following link for your calculation*

   *https://towardsdatascience.com/entropy-how-decision-trees-make-decisions-2946b9c18c8*

**Training Data**

| Color | Diameter | Label |
|---|---|---|
| Green | 3 | Apple |
| Yellow | 3 | Apple |
| Red | 1 | Grape |
| Red | 1 | Grape |
| Yellow | 3 | Lemon |

Based on these data, we can compute probability of Label target.

- Since probability is equal to frequency relative, we have
  P(Apple) = Prob (Apple) = 2 / 5
  P(Grape)= Prob (Grape) = 2 / 5
  P(Lemon)=Prob (Lemon) = 1 / 5

  So now we calculate the Entropy using the below formula:

$$E(S) = \sum_{i=1}^{c} - p_i \log_2 p_i$$

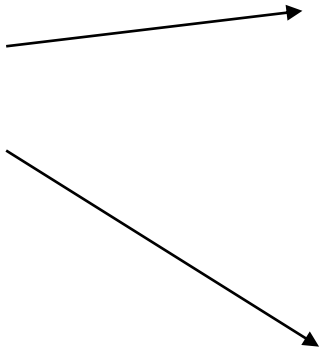
= -(2/5) * log2(2/5) -(2/5) * log2(2/5) -(1/5) * log2(1/5)
= 1.521

**1st Iteration: Find the root of a decision tree**

The Parent Data Table has classes of 2 Apple,2 Grape and 1 Lemon which produce entropy of 1.521

- Information Gain for Diameter

| Diameter | Label |
|---|---|
| 3 | Apple |
| 3 | Apple |
| 1 | Grape |
| 1 | Grape |
| 3 | Lemon |



| Diameter | Label |
|---|---|
| 3 | Apple |
| 3 | Apple |
| 3 | Lemon |

| Diameter | Label |
|---|---|
| 1 | Grape |
| 1 | Grape |

Entropy of Diameter 3 table = -(2/3) * log2(2/3) - (1/3) * log2(1/3)
= 0.918

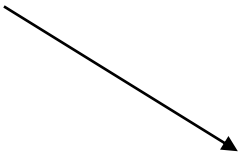
Entropy of Diameter 1 table = -(2/2) * log2(2/2)
= 0

The entropy of the Information Gain for Diameter
= 1.521 – (3/5 * 0.918 + 2/5 * 0)
= 0.970

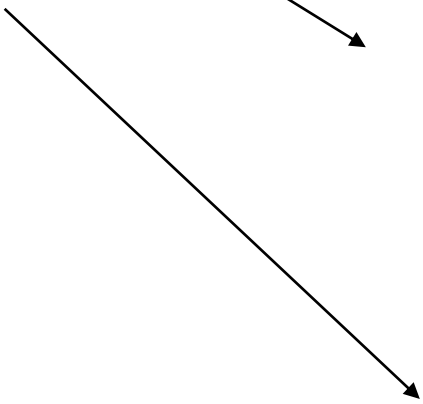
- Information Gain for Color

| Color | Label |
|---|---|
| Green | Apple |
| Yellow | Apple |
| Red | Grape |
| Red | Grape |
| Yellow | Lemon |

| Color | Label |
|---|---|
| Green | Apple |



| Color | Label |
|---|---|
| Yellow | Apple |
| Yellow | Lemon |



| Color | Label |
|---|---|
| Red | Grape |
| Red | Grape |

Entropy of Green table = -(1/1) * log2(1/1)
= 0

Entropy of Yellow table = -(1/2) * log2(1/2) - (1/2) * log2(1/2)
= 1

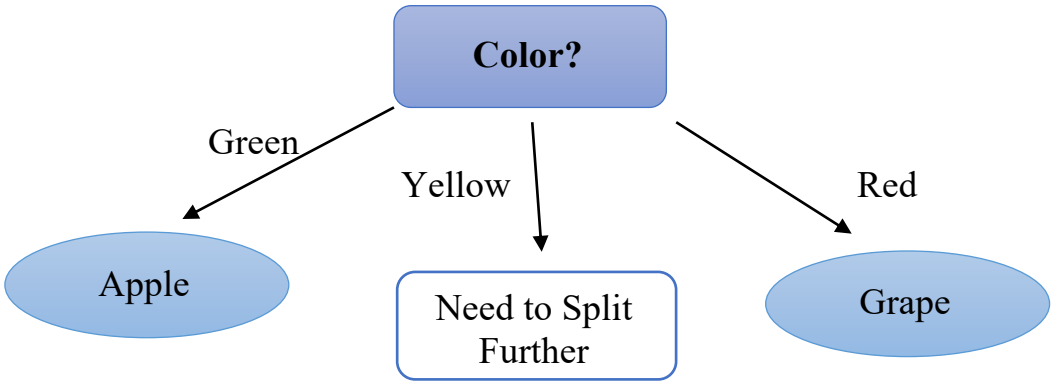
Entropy of Red table = -(2/2) * log2(2/2)
= 0

The entropy of the Information Gain for Color
= 1.521 – (1/5 * 0 + 2/5 * 1 + 2/5 * 0)
= 1.121

Table below summarizes the information gain for all four attributes.
Result of the First Iteration:

| Gain | Diameter | Color |
|---|---|---|
| Entropy | 0.970 | 1.121 |

- Color is selected as the root because it has the highest information gain.

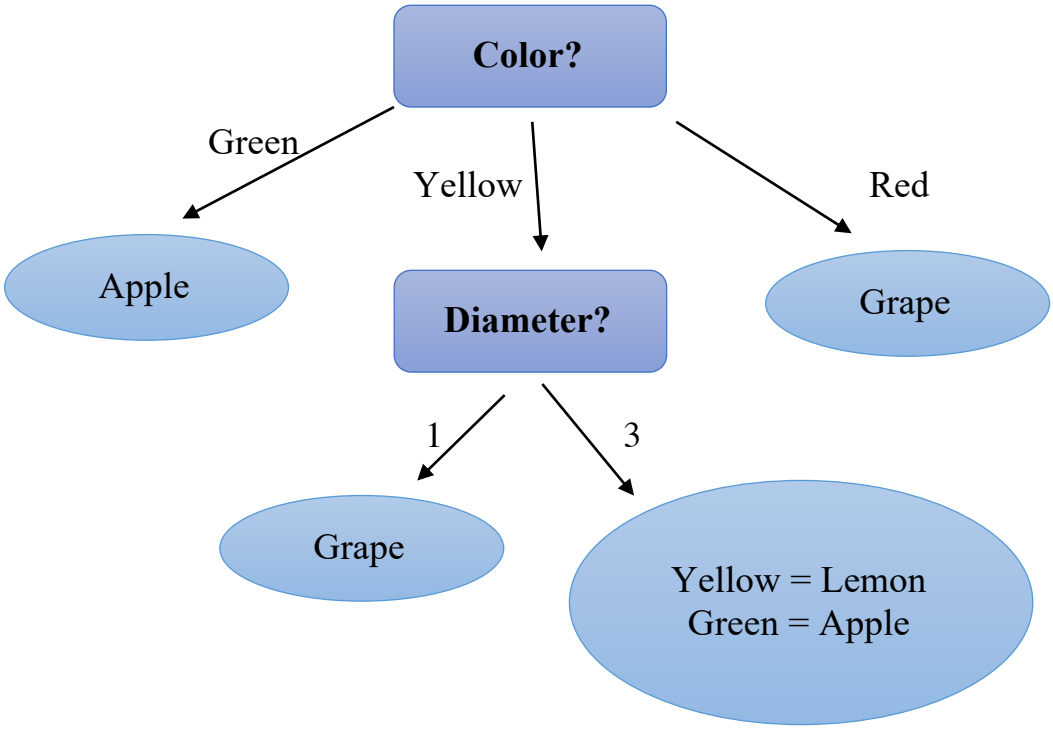



- Since Green and Red Color have been associated with pure class, we do not need these data any longer.
- For second iteration, our data table D come from the Yellow Color because it is not associated with pure class.

- As we have only 2 features Color and Diameter from which color is the root so further will diameter.

- Green color is Apple and Red color is Grape so with diameter 1 and 3, where 1 is grape and 3 is apple or lemon from which apple is gone with color.

- Hence diameter = 3 is lemon associated with yellow color.


Color?
Green
Yellow
Red
Apple
Diameter?
Grape
1
3
Grape
Yellow = Lemon
Green = Apple