

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| Yes           | 12  | Blue           | Yes           |
| Yes           | 87  | Green          | Yes           |
| No            | 44  | Blue           | No            |
| Yes           | 19  | Red            | No            |
| No            | 32  | Green          | Yes           |
| No            | 14  | Blue           | Yes           |

Convert Categorical Data  
To Numerics

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

| <i>Likes Popcorn</i> | <i>Age</i> | <i>Favorite Color</i> | <i>Loves Troll 2</i> |
|----------------------|------------|-----------------------|----------------------|
| 1                    | 12         | 1                     | 1                    |
| 1                    | 87         | 2                     | 1                    |
| 0                    | 44         | 1                     | 0                    |
| 1                    | 19         | 3                     | 0                    |
| 0                    | 32         | 2                     | 1                    |
| 0                    | 14         | 1                     | 1                    |

دقت نیس بی اولیه

0.5

← تفسیر: احتمال Yes بود

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual

-0.5  
-0.5  
+0.5  
+0.5  
-0.5  
-0.5

رصفت پیس بسی اولیه

0.5

حال Residual ها را برای هر داده

محاسبه کنیم (  $\hat{y}_j - y_j$  )

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

حل معادل Residual اور بزرگتر

می دھیں و Similarity Score می لئے راحاب میں

( $\sum_{i=1}^6 \text{Residual}_i$ )

$\frac{\sum_{i=1}^6 [\text{Prev. Prob.}_i \times (1 - \text{Prev. Prob.}_i)]}{\sum_{i=1}^6 \text{Residual}_i}$

فرض یہ سب سی اولیہ

0.5

-0.5, -0.5, +0.5, +0.5, -0.5, -0.5

Sim. score

$$\frac{(-0.5 - 0.5 + 0.5 + 0.5 - 0.5 - 0.5)^2}{6 \times 0.5 \times (1 - 0.5)} = 0.66$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual

- 0.5
- 0.5
- +0.5
- +0.5
- 0.5
- 0.5

دست بیس بسی اولیه

0.5

Sim. score

0.66

حل بای Split های مختلف را برای کردن و بر

نمایش gain برویم

0.5 ← Like Popcorn

65.5, 38, 25.5, 16.5, 13 ← Age

2.5 و 1.5 ← Fav. Color

-0.5, -0.5, +0.5, +0.5, -0.5, -0.5

Split های مکانی

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

دھنے پس بی اولیہ

0.5

اولیہ Split

0.66

Like Popcorn < 0.5

+0.5, -0.5  
 -0.5

-0.5, -0.5  
 +0.5

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual

-0.5  
-0.5  
+0.5  
+0.5  
-0.5  
-0.5

دقت نیست اولیه

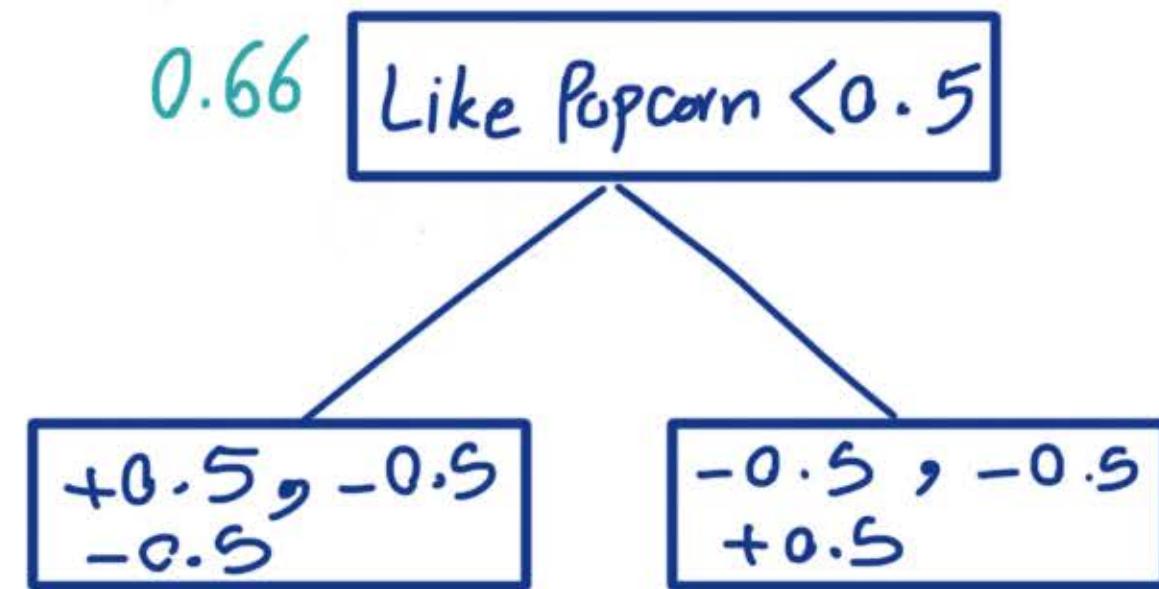
0.5

similarity score =

$$\frac{(0.5 - 0.5 - 0.5)^2}{3 \times 0.25} = 0.33$$

اولین Split

0.66



| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

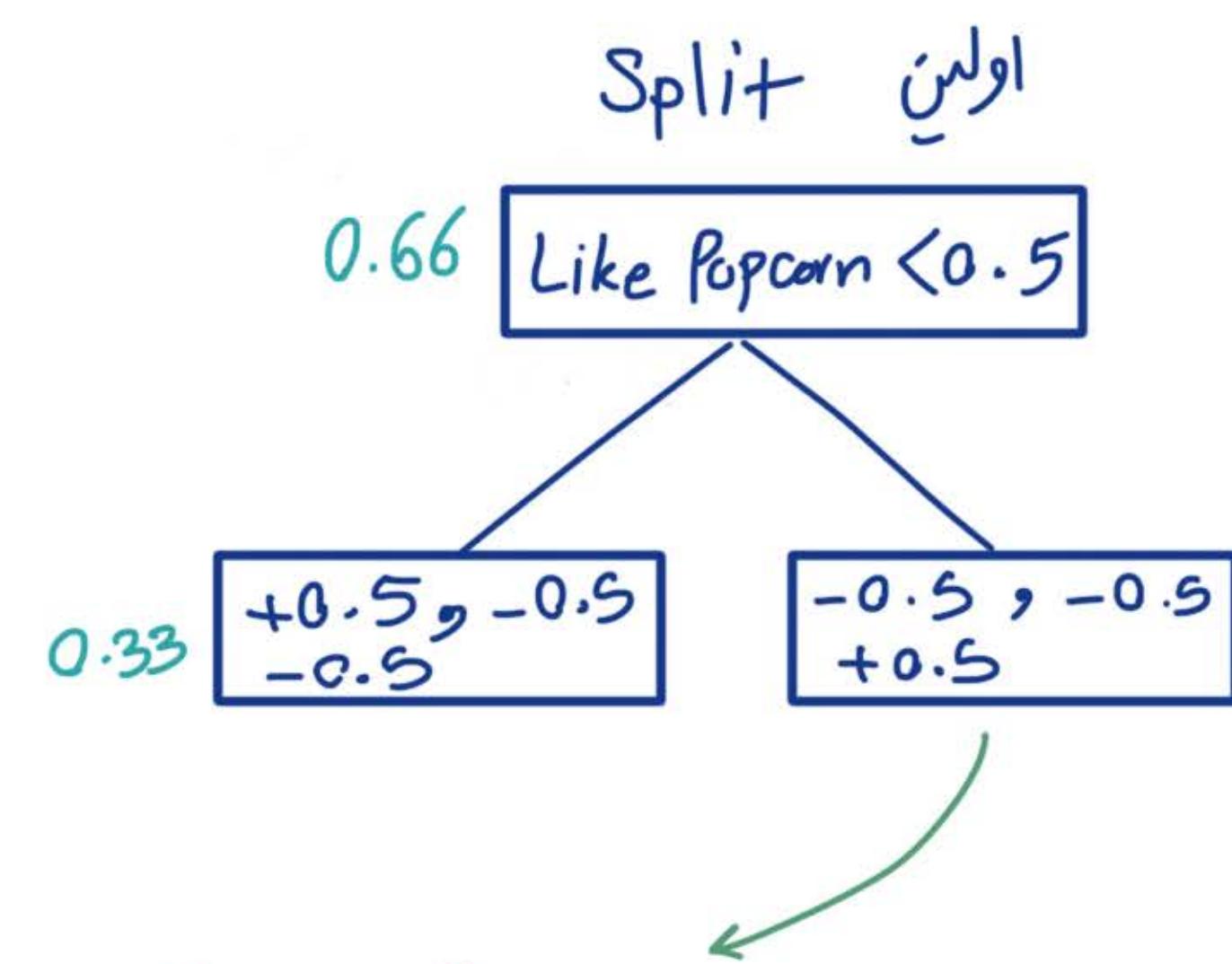
Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

دقت نیست اولیه

0.5

similarity score =

$$\frac{(0.5 - 0.5 - 0.5)^2}{3 \times 0.25} = 0.33$$



| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

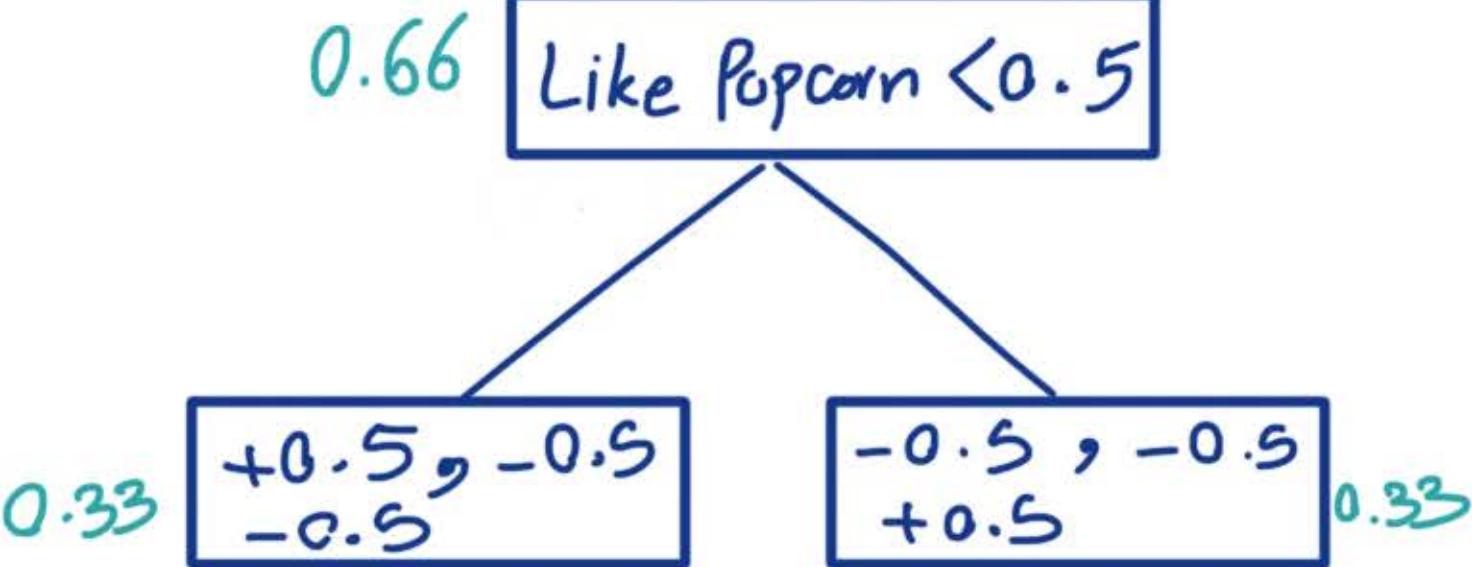
Residual

-0.5  
-0.5  
+0.5  
+0.5  
-0.5  
-0.5

دقت نیست اولین

0.5

Split اولین



$$\text{Gain} = \frac{\text{Similarity}_{\text{Left}} + \text{Similarity}_{\text{Right}}}{\text{Similarity}_{\text{Root}}}$$

$$= 0.33 + 0.33 - 0.66 = 0$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual

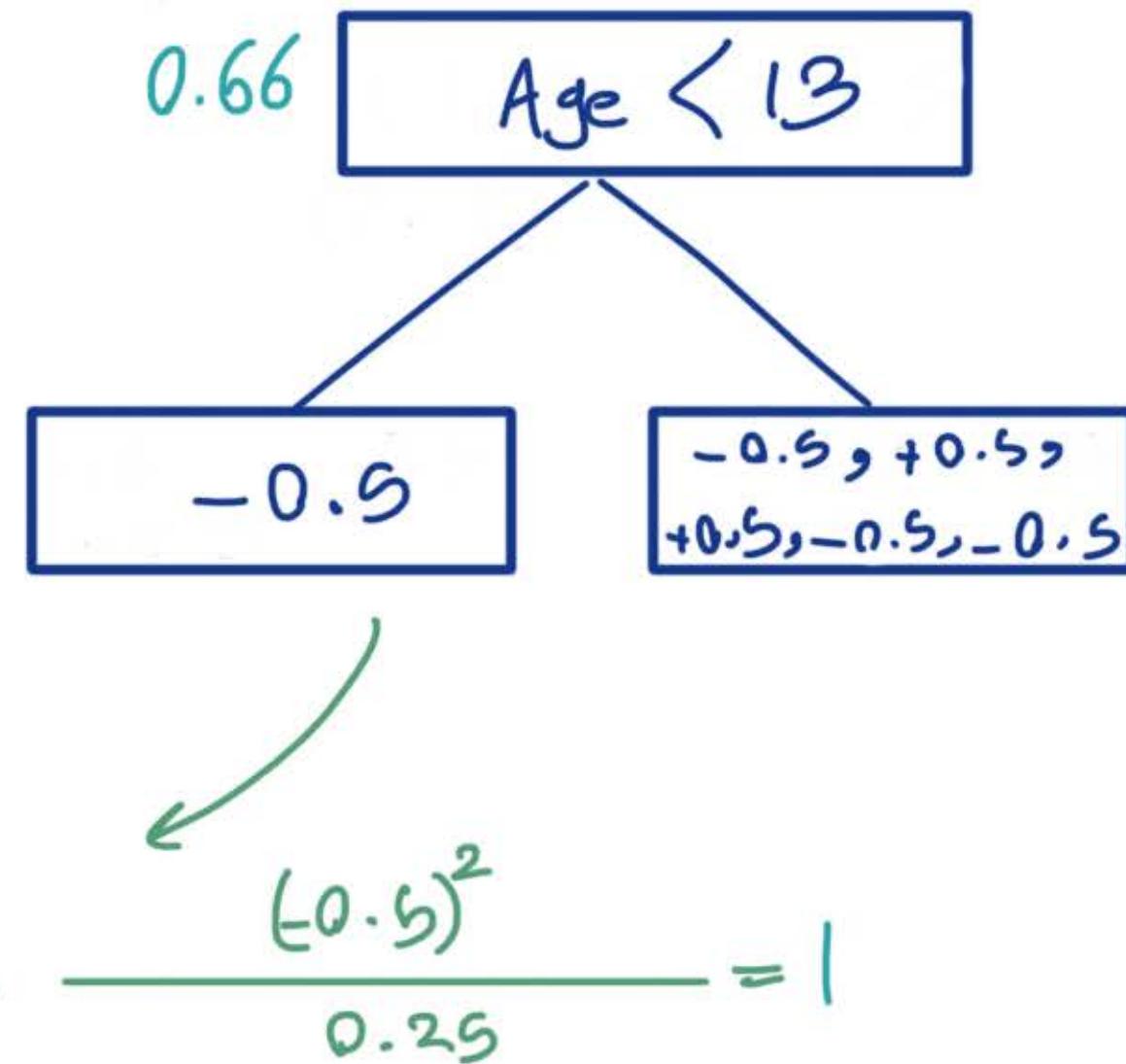
-0.5  
-0.5  
+0.5  
+0.5  
-0.5  
-0.5

دقت نیست بسی اولیه

0.5

Split دوین

0.66



| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual

-0.5  
-0.5  
+0.5  
+0.5  
-0.5  
-0.5

دقت نیست بسی اولیه

0.5

Split دوین

0.66

Age < 13

-0.5

-0.5, +0.5,  
+0.5, -0.5, -0.5

Similarity Score =  $\frac{(-0.5 + 0.5 + 0.5 - 0.5 - 0.5)^2}{5 \times 0.25} = 0.2$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual

-0.5  
-0.5  
+0.5  
+0.5  
-0.5  
-0.5

دھنے سے بیسی اولیہ

0.5

Split دوں

0.66

Age < 13

-0.5

-0.5, +0.5,  
+0.5, -0.5, -0.5

0.2

$$\text{Gain} = 1 + 0.2 - 0.66 \\ = 0.54$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual

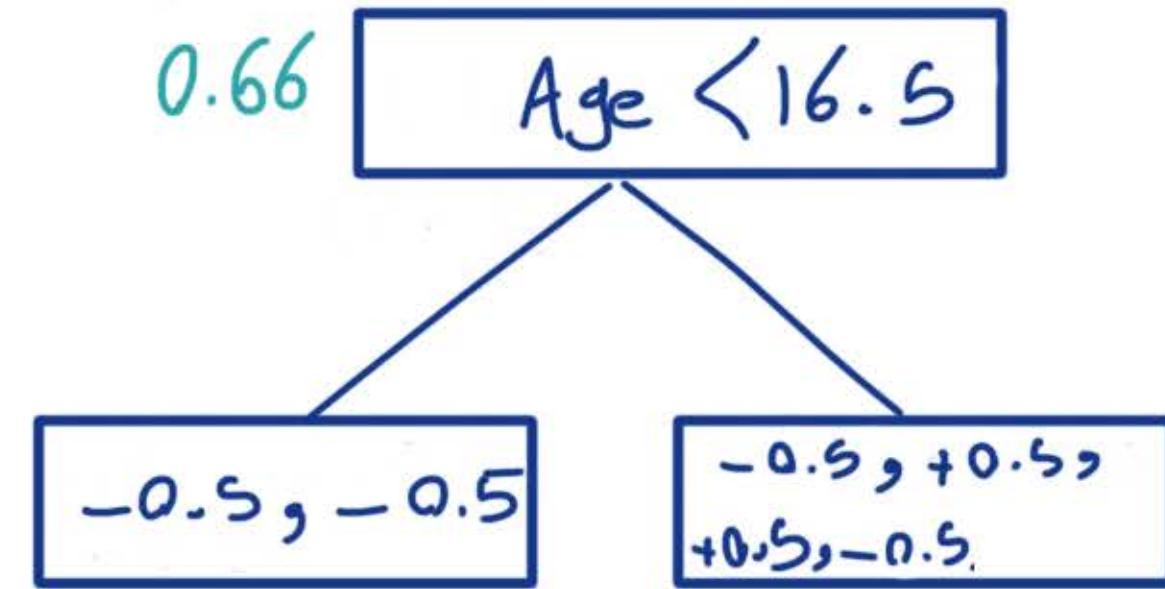
-0.5  
-0.5  
+0.5  
+0.5  
-0.5  
-0.5

دقت نیست بسی اولیہ

0.5

Split سوچن

0.66



Similarity score =  $\frac{(-0.5 - 0.5)^2}{2 \times 0.25} = 2$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual

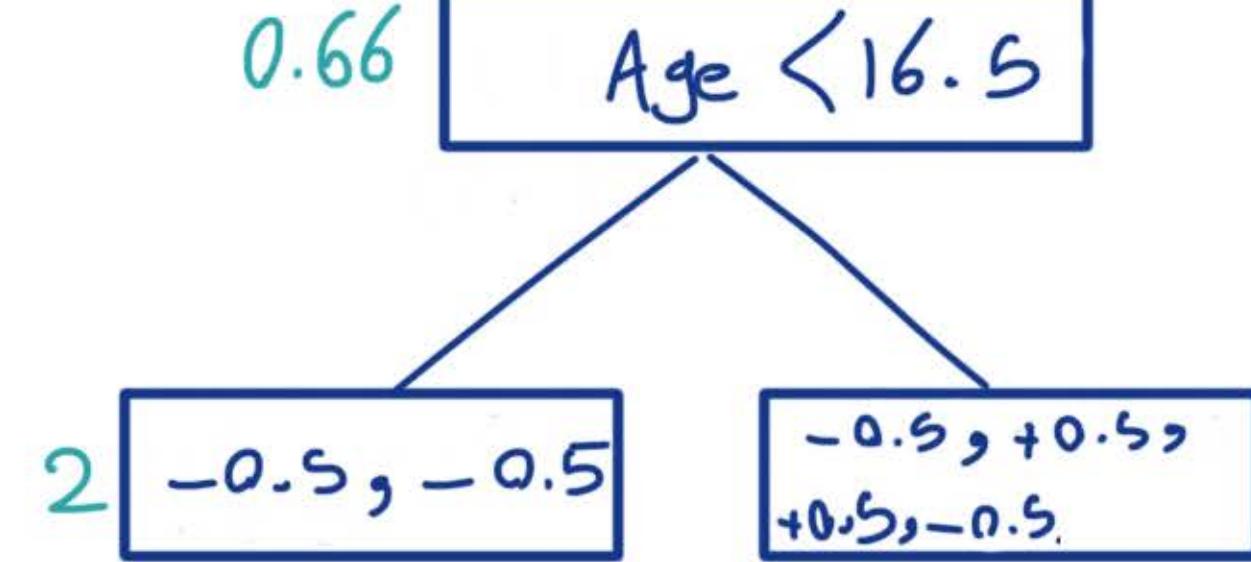
-0.5  
-0.5  
+0.5  
+0.5  
-0.5  
-0.5

دقت نیست بسی اولیہ

0.5

Split سوچن

0.66



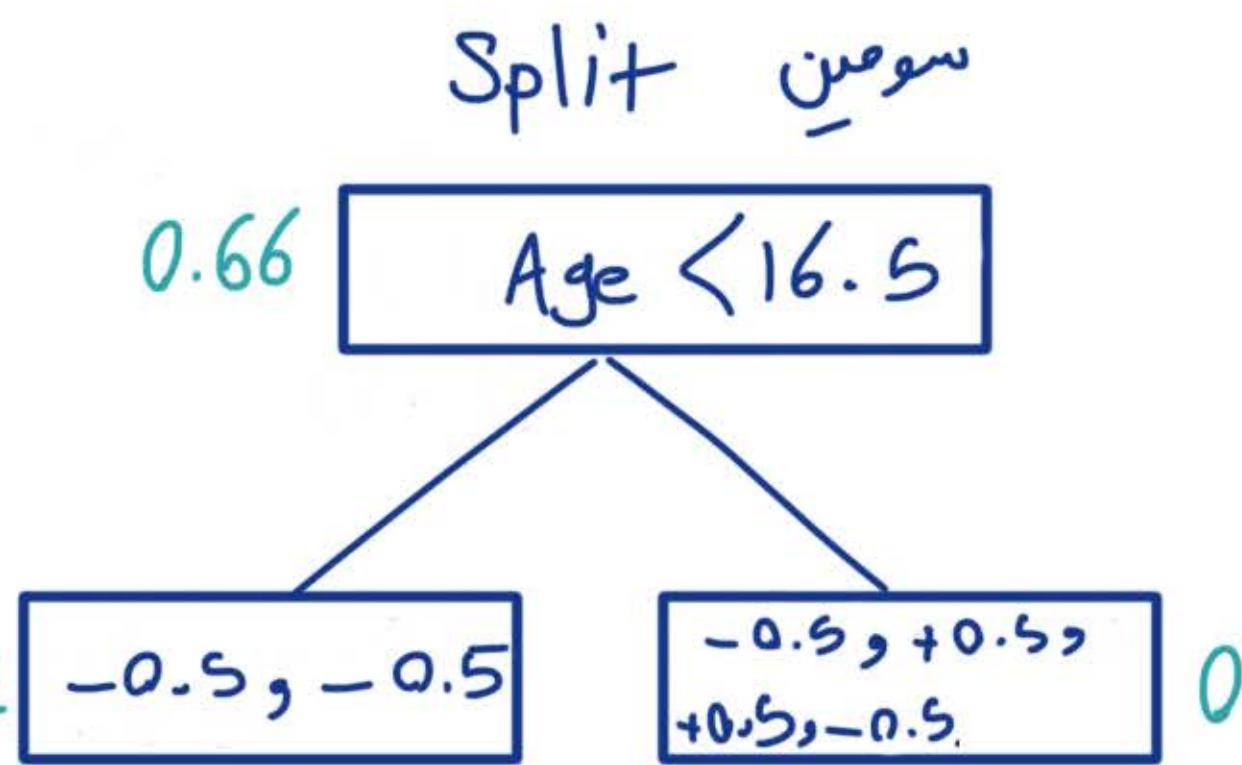
Similarity Score =  $\frac{(-0.5 + 0.5 + 0.5 - 0.5)^2}{4 \times 0.25} = 0$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

دقت نیست بسی اولیه

0.5



$$\text{Gain} = 2 + 0 - 0.66 = 1.34$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual

-0.5  
-0.5  
+0.5  
+0.5  
-0.5  
-0.5

Split حارض

0.66

Age < 25.5

-0.5, +0.5, -0.5

-0.5, +0.5, -0.5

دقت نیس بی اولیہ

0.5

$$\text{Sim score} = \frac{(-0.5 + 0.5 - 0.5)^2}{3 \times 0.25} = 0.33$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual

-0.5  
-0.5  
+0.5  
+0.5  
-0.5  
-0.5

Split حارض

0.66

Age < 25.5

0.33

-0.5, +0.5, -0.5

-0.5, +0.5, -0.5

دقت نیست اولیه

0.5

$$\text{Sim score} = \frac{(-0.5 + 0.5 - 0.5)^2}{3 \times 0.25} = 0.33$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

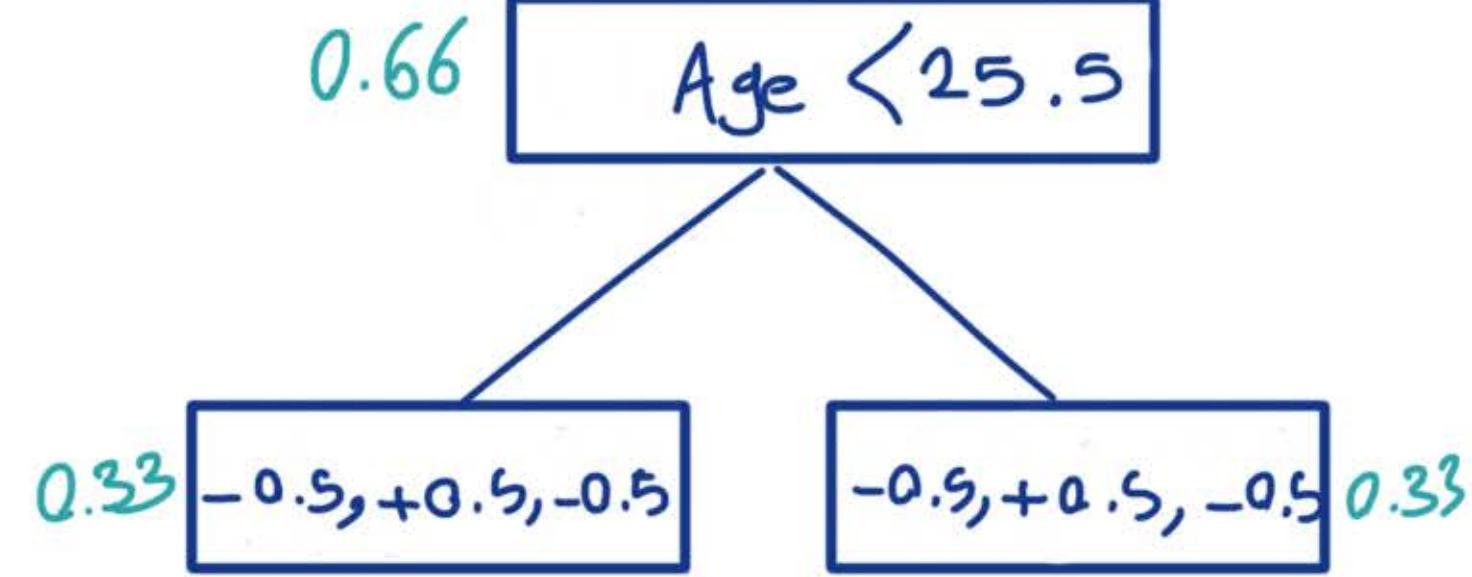
Residual

-0.5  
-0.5  
+0.5  
+0.5  
-0.5  
-0.5

دھنے پس بی اولیہ

0.5

Split حمار من

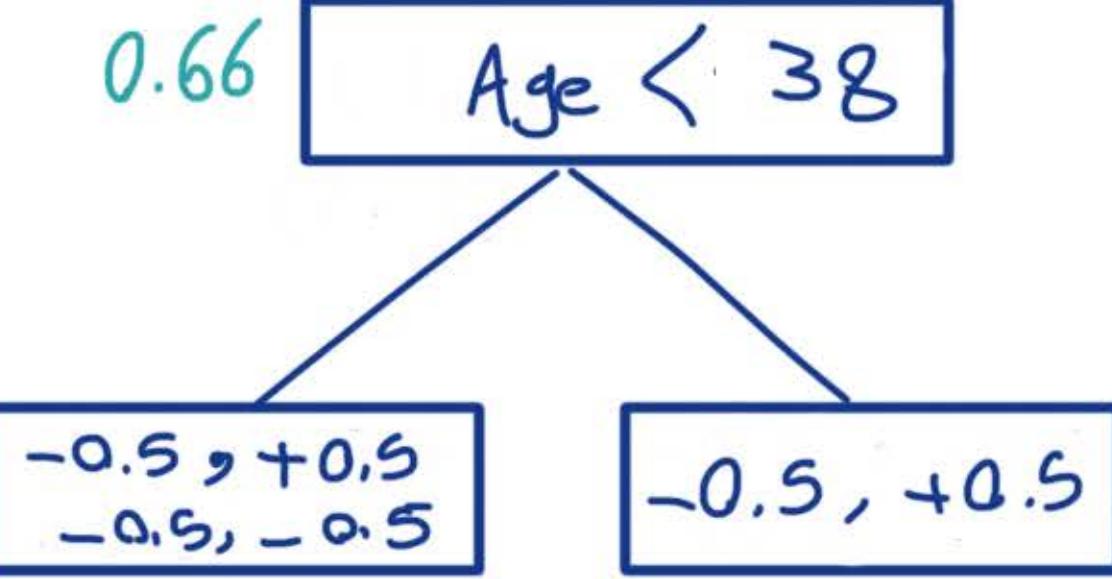


Gain =  $0.33 + 0.33 - 0.66 = 0$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

Split بحسمين



صرف نیس بسی اولیہ

0.5

Sim Score =  $\frac{(-0.5 + 0.5 - 0.5 - 0.5)^2}{4 \times 0.25} = 1$

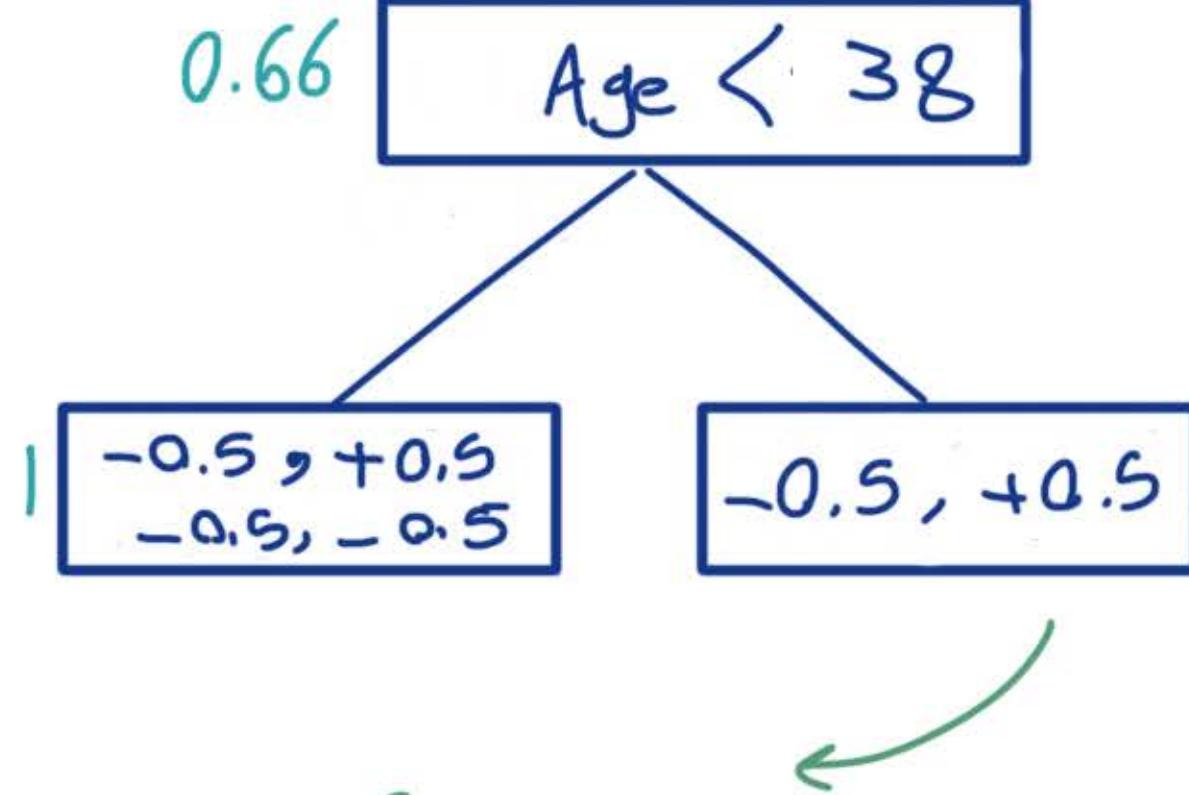
| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

Split بحسم

صرف پس بسی اولیہ

0.5



$$\text{Sim Score} = \frac{(-0.5 + 0.5)^2}{2 \times 0.25} = 0$$

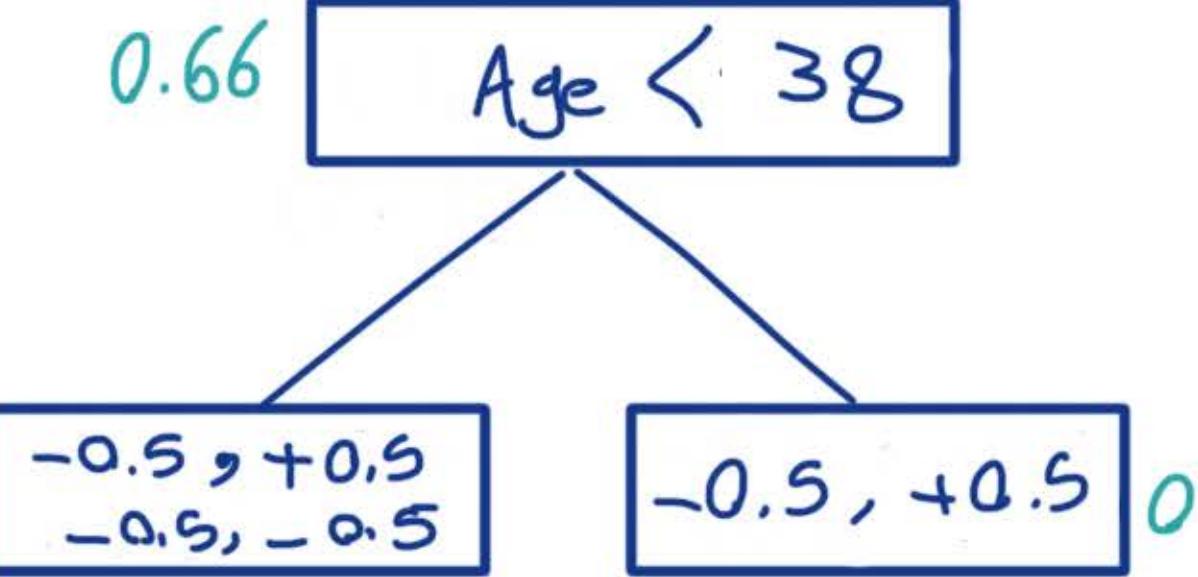
| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

دھنی اولیہ

0.5

Split دھنیں



$$\text{Gain} = 1 + 0 - 0.66 = 0.33$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

Split سُنْعَانٌ

0.66 Age < 65.5

-0.5, +0.5, +0.5  
 , -0.5, -0.5

-0.5

دھنٰت لیس بی اولیہ

0.5

$$\text{Sim. Score} = \frac{(-0.5 + 0.5 + 0.5 - 0.5 - 0.5)^2}{5 \times 0.25} = 0.2$$

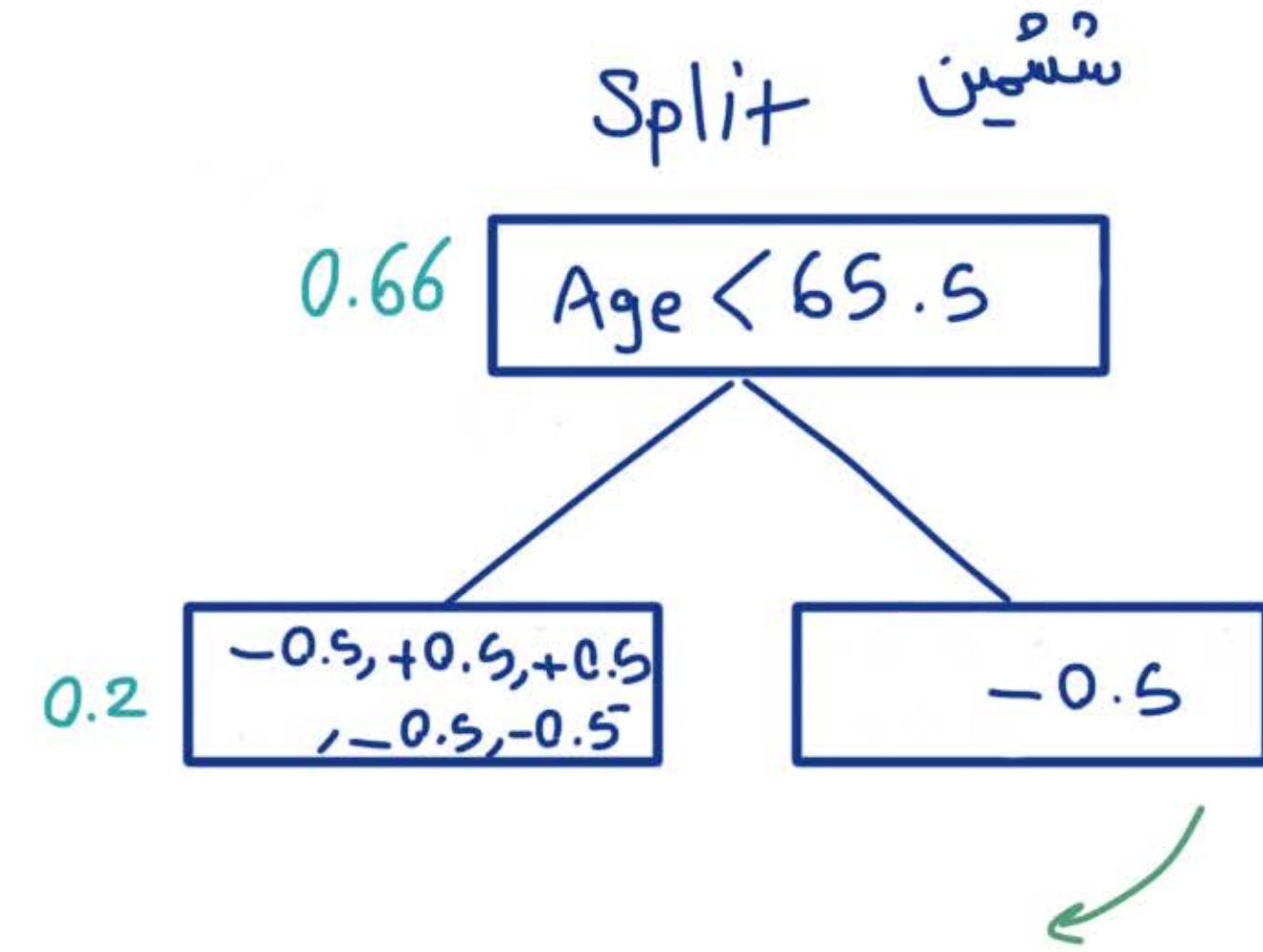
| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

دھنے پس بی اولیہ

0.5

$$\text{Sim. Score} = \frac{(-0.5)^2}{0.25} = 1$$



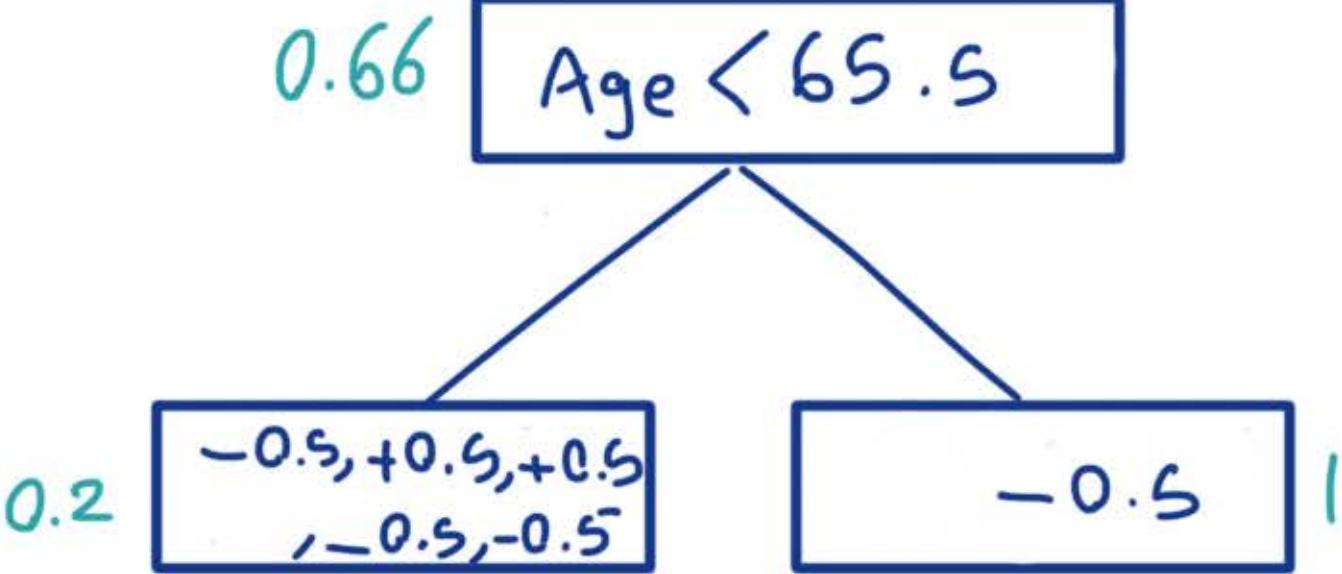
| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

دھنے پس بی اولیہ

0.5

Split شیئن



$$\text{Gain} = 0.2 + 1 - 0.66 = 0.54$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual

-0.5  
-0.5  
+0.5  
+0.5  
-0.5  
-0.5

دقت نیست بسی اولیه

0.5

Split مفہوم

0.66

Far. Color < 1.5

-0.5, +0.5, -0.5

-0.5, +0.5, -0.5



Sim Score =  $\frac{(-0.5 + 0.5 - 0.5)^2}{3 \times 0.25} = 0.33$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual

-0.5  
-0.5  
+0.5  
+0.5  
-0.5  
-0.5

دقت نیست بسی اولیه

0.5

Split مفہوم

0.66

Far. Color < 1.5

0.33

-0.5, +0.5, -0.5

-0.5, +0.5, -0.5

$$\text{Sim Score} = \frac{(-0.5 + 0.5 - 0.5)^2}{3 \times 0.25} = 0.33$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

دھنے پس بی اولیہ

0.5

Split مفہوم

0.66 Far. Color < 1.5

0.33 -0.5, +0.5, -0.5

-0.5, +0.5, -0.5

0.33

$$\text{Gain} = 0.33 + 0.33 - 0.66 = 0$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual

-0.5  
-0.5  
+0.5  
+0.5  
-0.5  
-0.5

Split هستهین

0.66 Far. Color < 2.5

-0.5, -0.5, +0.5  
-0.5, -0.5

+0.5

دقت نیس بسی اولیہ

0.5

$$\text{Sim Score} = \frac{(-0.5 - 0.5 + 0.5 - 0.5 - 0.5)^2}{5 \times 0.25} = 1.8$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual

-0.5  
-0.5  
+0.5  
+0.5  
-0.5  
-0.5

Split هستهین

0.66

Far. Color < 2.5

-0.5, -0.5, +0.5  
-0.5, -0.5

+0.5

دقت نیس بسی اولیہ

0.5

1.8

$$\text{Sim Score} = \frac{(0.5)^2}{0.25} = 1$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual

-0.5  
-0.5  
+0.5  
+0.5  
-0.5  
-0.5

دقت نیس بسی اولیہ

0.5

Split هستین

0.66

Far. Color < 2.5

-0.5, -0.5, +0.5  
-0.5, -0.5

+0.5

$$\text{Gain} = 1.8 + 1 - 0.66 = 2.14$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

Split هسته میں

0.66 Far. Color < 2.5

-0.5, -0.5, +0.5  
 -0.5, -0.5

+0.5

دھنٹ لیس بسی اولیہ

0.5

وہ این Split بسی ریجن Gain را فیب ما جائے.

حال بایہ بے سرانح سماحتی سمعت چپ رفتہ و آن را

کنیم. split

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

### Residual

-0.5  
-0.5  
+0.5  
+0.5  
-0.5  
-0.5

0.66

Far. Color < 2.5

1.8

-0.5, -0.5, +0.5  
-0.5, -0.5

+0.5

دقت نیس بسی اولیه

0.5

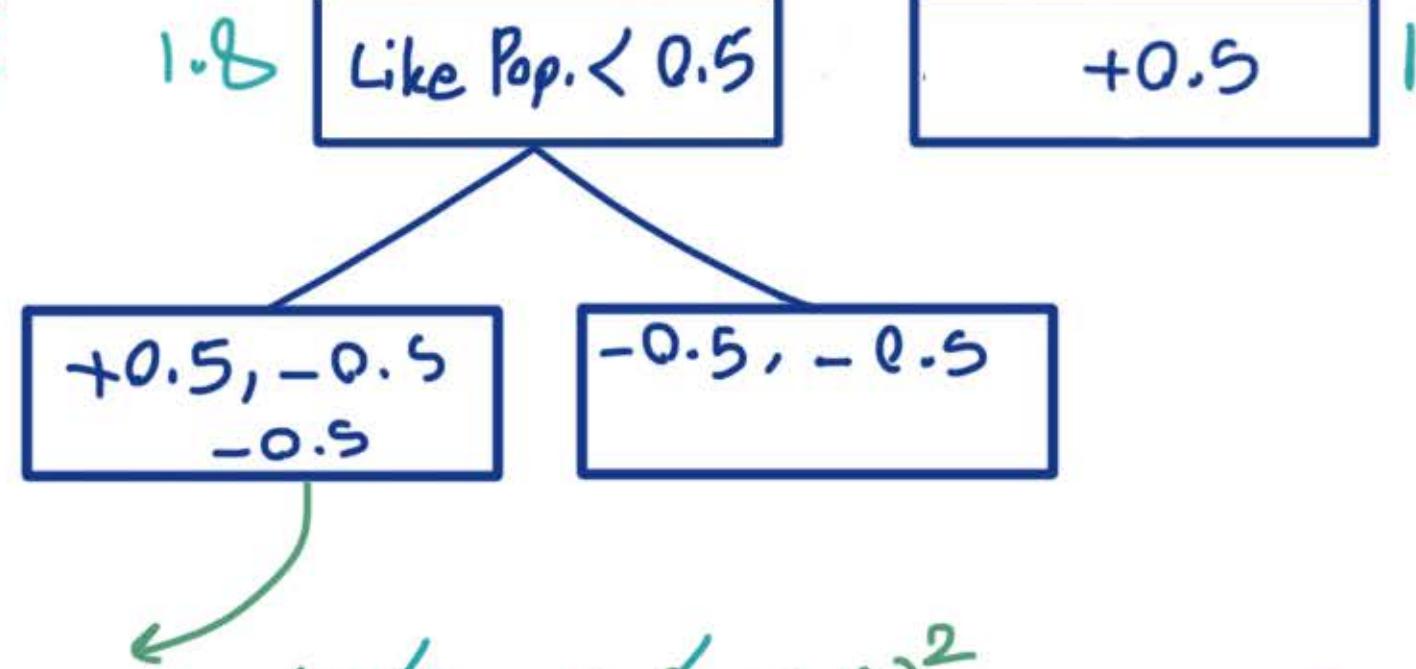
0.5 ← Like Popcorns  
 65.5, 38, 23, 13 ← Age → جویی های مدلن ساخت Split  
 1.5 ← Far. color

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

0.66

Far. Color < 2.5



دھنے پس بی اولیہ

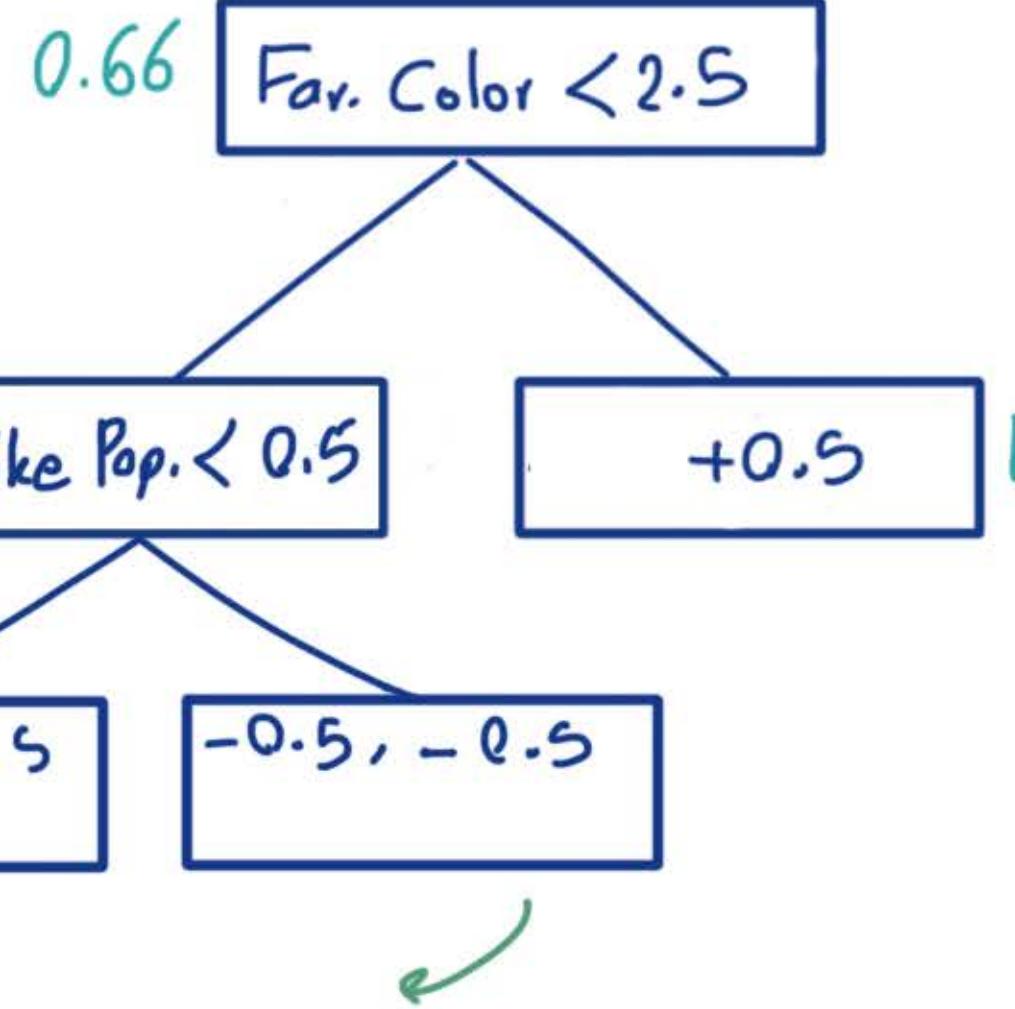
0.5

Sim. Score

$$\text{Sim. Score} = \frac{(0.5 - 0.5 - 0.5)^2}{3 \times 0.25} = 0.33$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5



دھنے پس بی اولیہ

0.5

$$\text{Sim. Score} = \frac{(-0.5 \quad -0.5)^2}{2 \times 0.25} = 2$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

0.66

Far. Color < 2.5

1.8

Like Pop. < 0.5

+0.5

0.33

+0.5, -0.5  
 -0.5

-0.5, -0.5

2

دھنے پس بی اولیہ

0.5

$$\text{Gain} = 2 + 0.33 - 1.8 = 0.53$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

0.66 Far. Color < 2.5

1.8

Age < 13

+0.5

-0.5, +0.5  
 -0.5, -0.5



$$\text{Sim. Score} = \frac{(-0.5)^2}{0.25} = 1$$

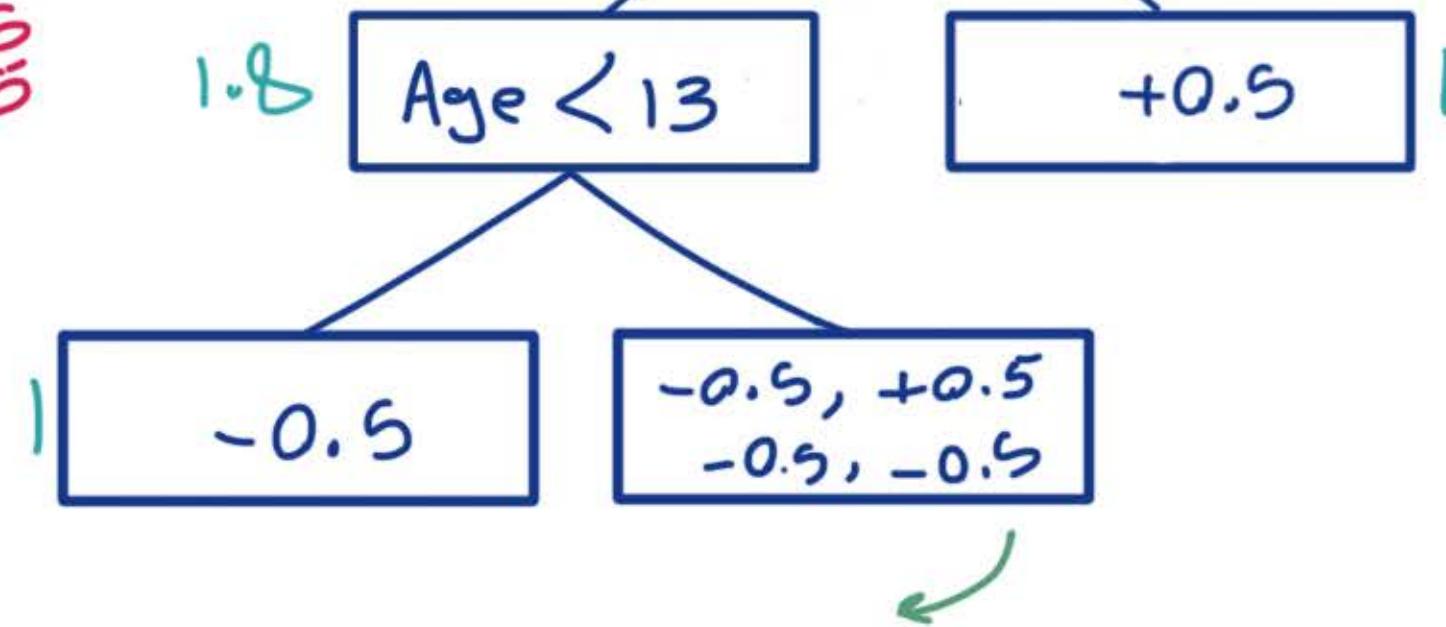
دھنے پس بی اولیہ

0.5

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

0.66 Far. Color < 2.5



دقتیں بسی اولیے

0.5

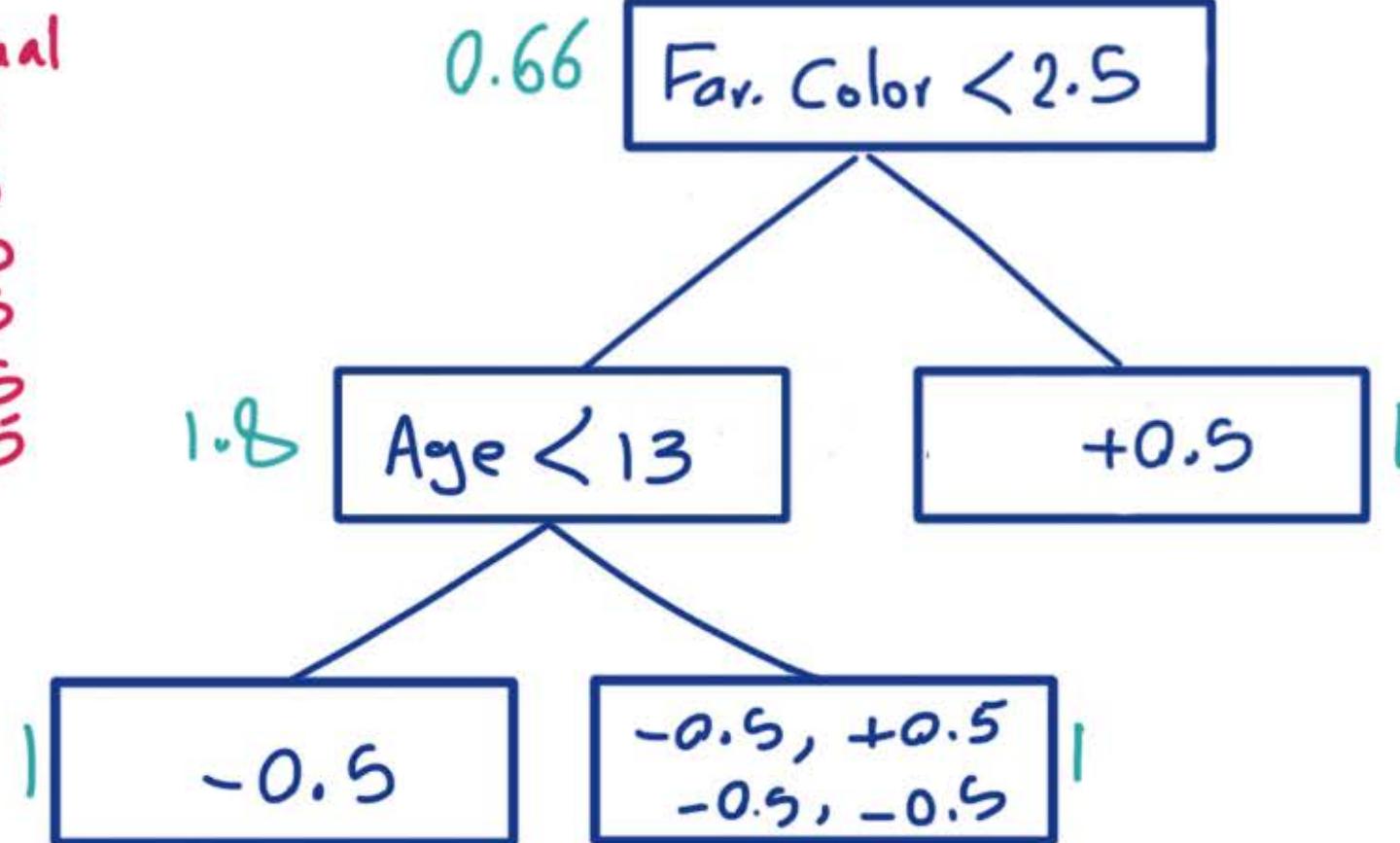
$$\text{sim. score} = \frac{(-0.5 + 0.5 - 0.5 - 0.5)^2}{4 \times 0.25} = 1$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

دھنے پس بی اولیہ

0.5

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5



$$\text{Gain} = 1 + 1 - 1.8 = 0.2$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

0.66 Far. Color < 2.5

1.8

Age < 23

+0.5

-0.5, -0.5

-0.5, +0.5, -0.5

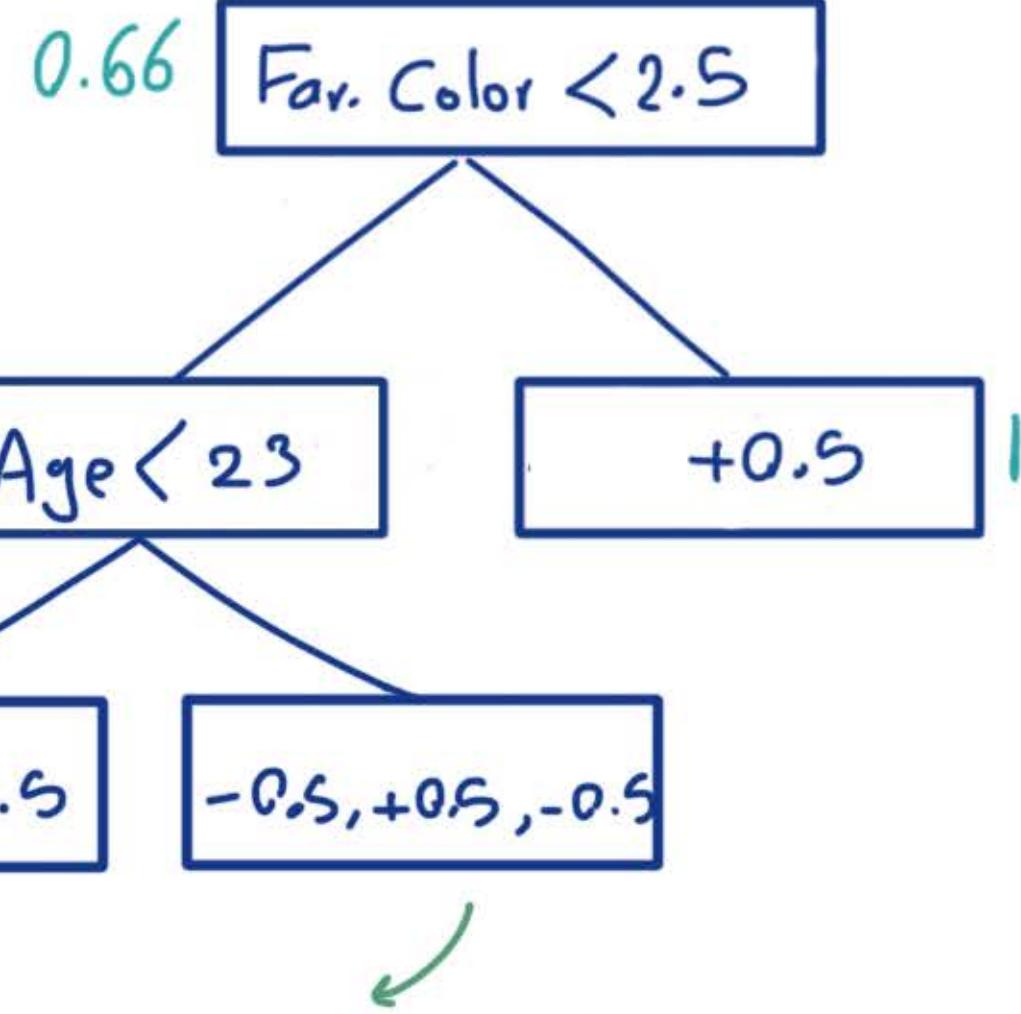
دھنے پس بی اولیہ

0.5

$$\text{Sim Score} = \frac{(-0.5 - 0.5)^2}{2 \times 0.25} = 2$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5



$$\text{Sim Score} = \frac{(-0.5 + 0.5 - 0.5)^2}{3 \times 0.25} = 0.33$$

دھنے پس بی اولیہ

0.5

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

1.8

2

0.66

Far. Color < 2.5

+0.5

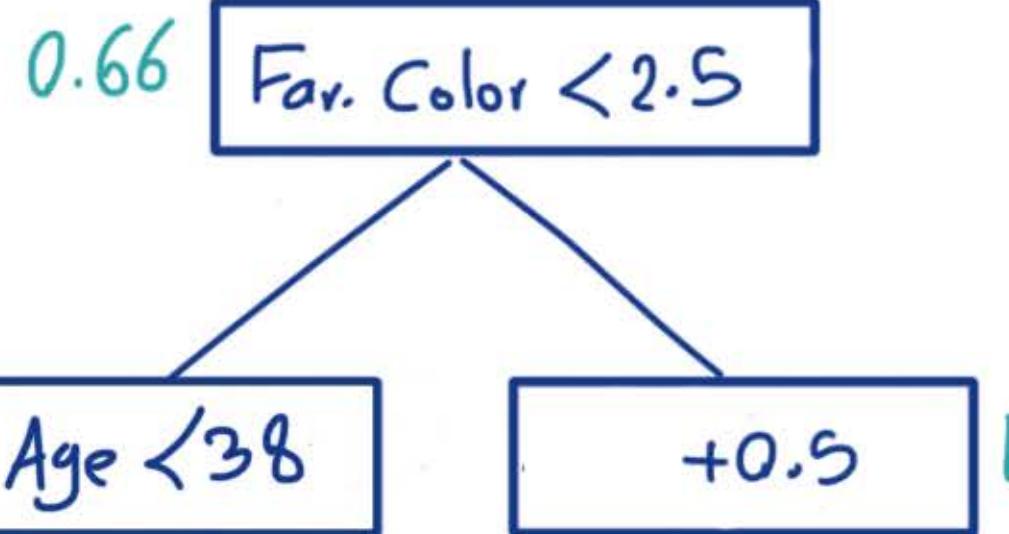
دھنے پس بی اولیہ

0.5

$$\text{Gain} = 2 + 0.33 - 1.8 = 0.53$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5



دھنے پس بی اولیہ

0.5

Sim score =  $\frac{(-0.5 - 0.5 - 0.5)^2}{3 \times 0.25} = 3$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

0.66

Far. Color < 2.5

1.8

Age < 38

+0.5

3

-0.5, -0.5, -0.5

-0.5, +0.5



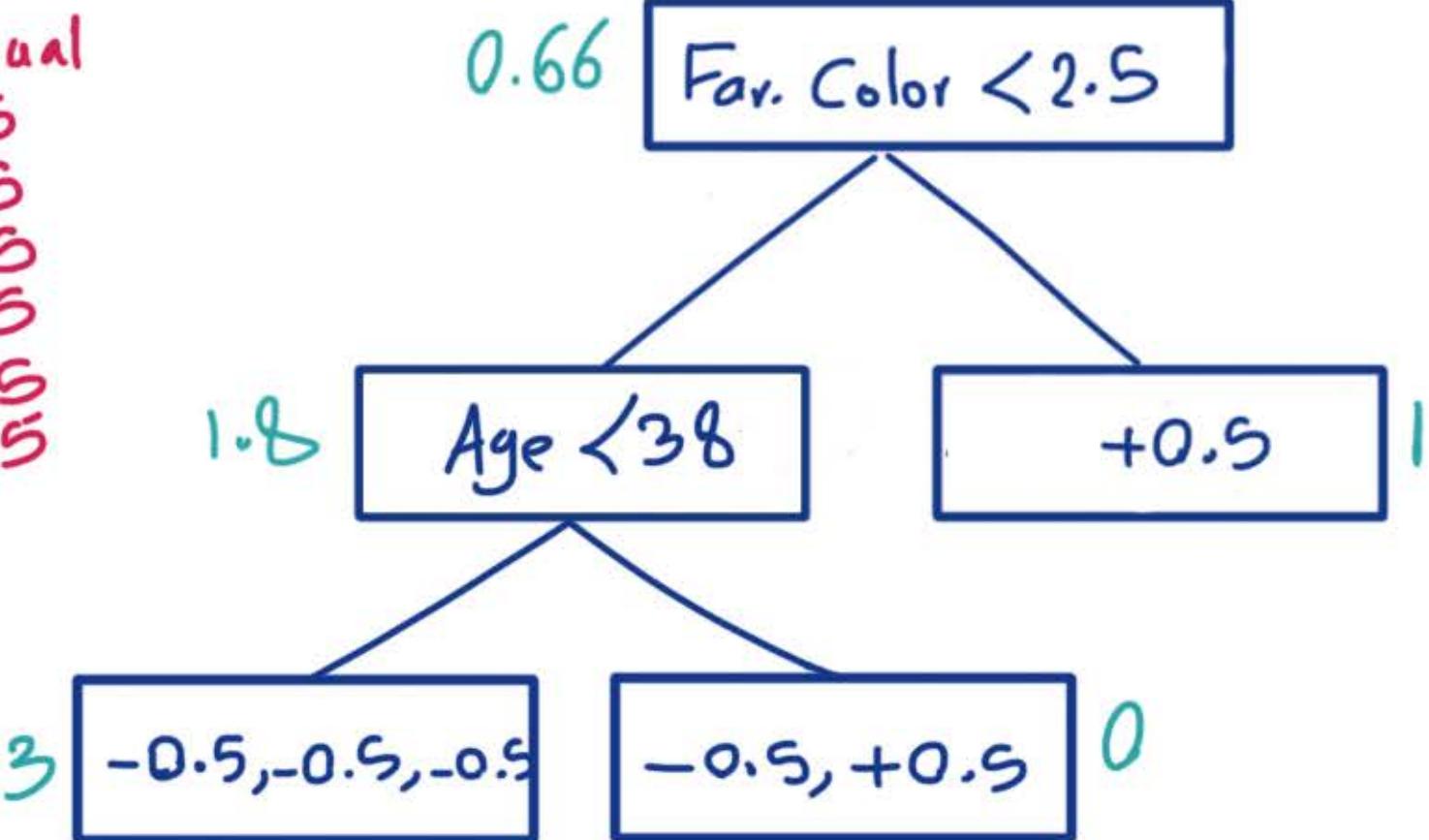
Sim score =  $\frac{(-0.5 + 0.5)^2}{2 \times 0.25} = 0$

دھنے پس بی اولیہ

0.5

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5



دھنے پس بی اولیہ

0.5

$$Gain = 3 + 0 - 1.8 = 1.2$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

0.66

Far. Color < 2.5

1.8

Age < 65.5

+0.5

-0.5, +0.5  
 -0.5, -0.5

-0.5

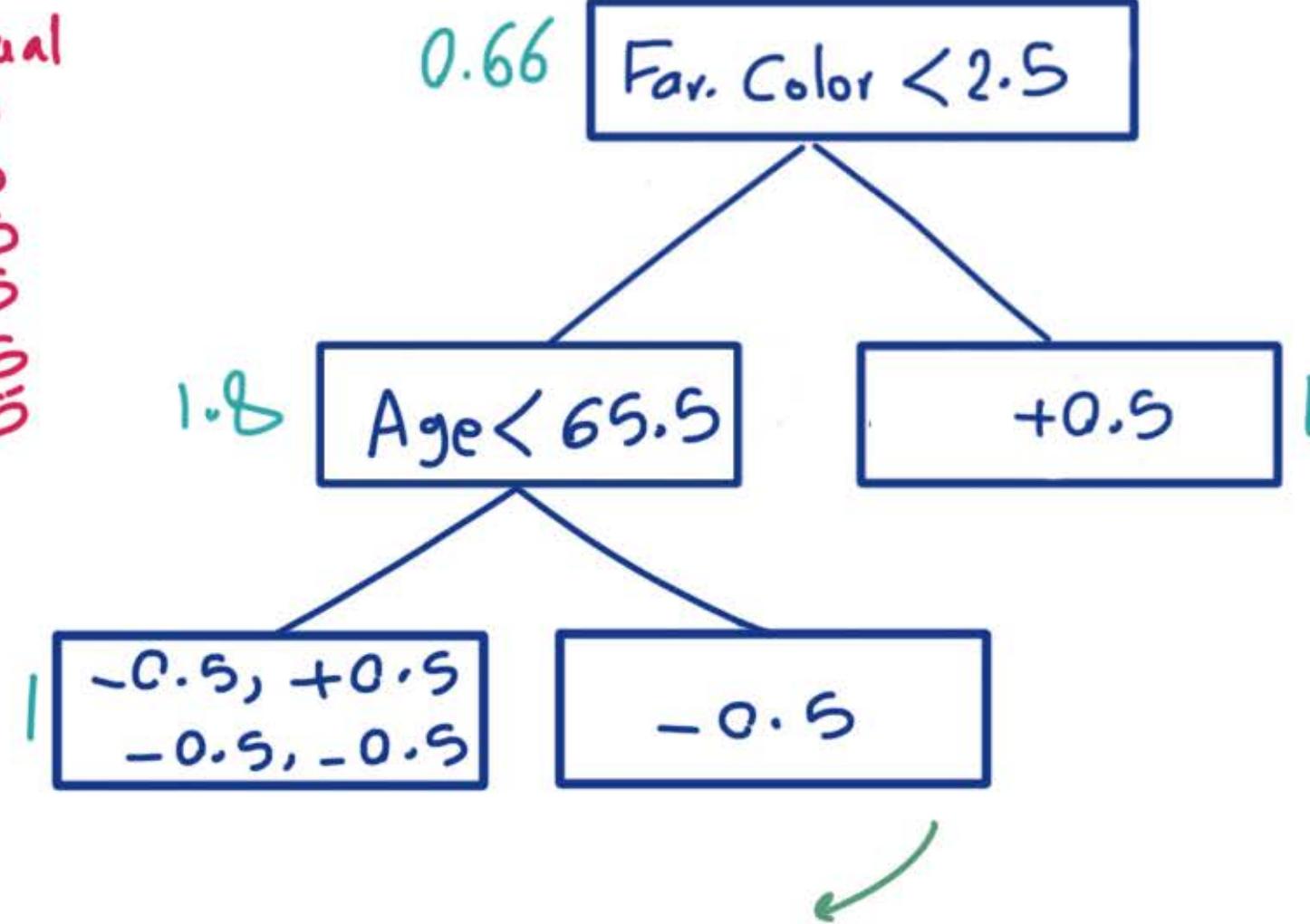
دھنے پس بی اولیہ

0.5

Sim. score =  $\frac{(-0.5 + 0.5 - 0.5 - 0.5)^2}{4 \times 0.25} = 1$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5



Sim. Score =  $\frac{(-0.5)^2}{0.25} = 1$

دھنے پس بی اولیہ

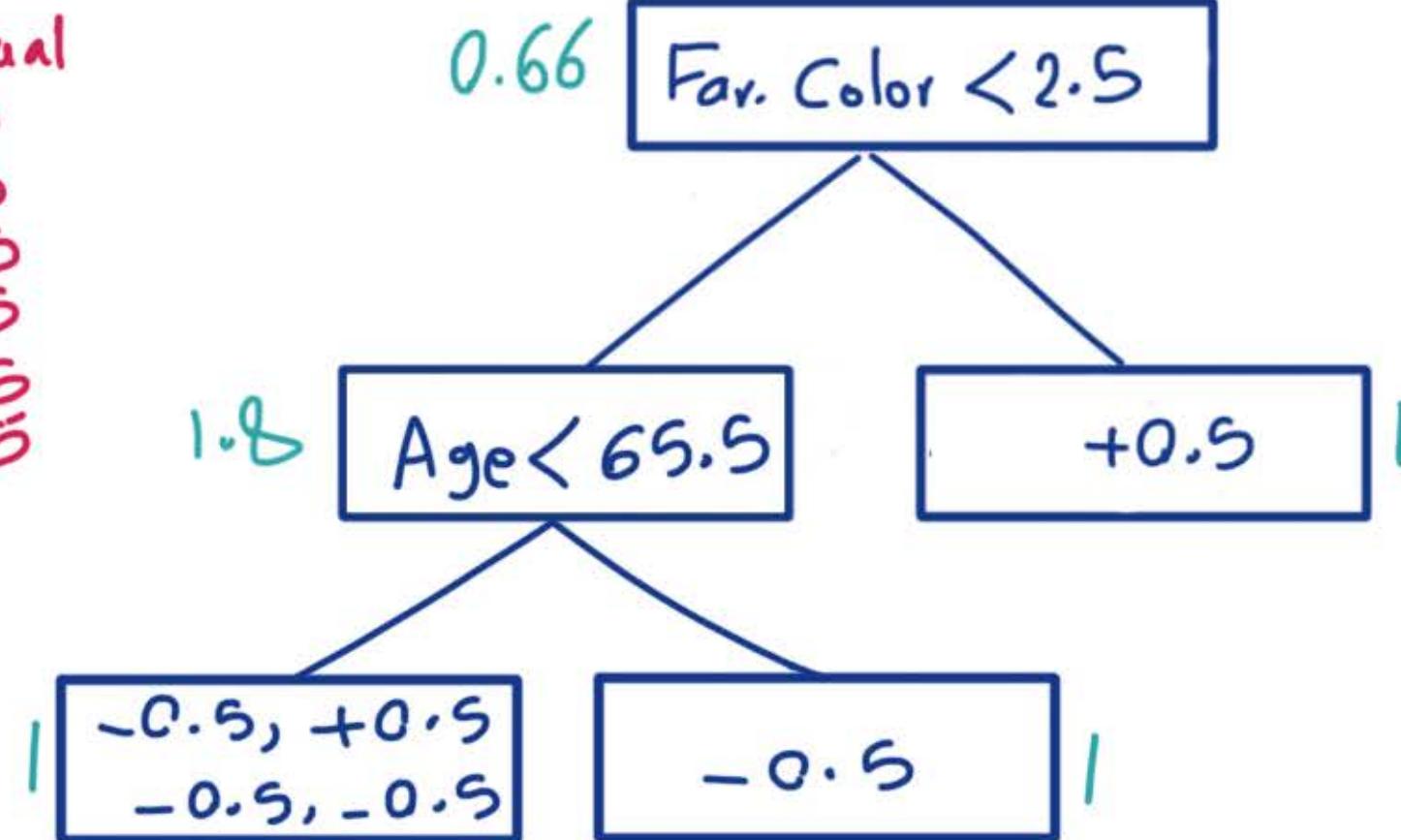
0.5

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

دھنے پس بی اولیہ

0.5

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5



$$\text{Gain} = 1 + 1 - 1.8 = 0.2$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

0.66 Far. Color < 2.5

1.8 Far. Color < 1.5 +0.5

-0.5, +0.5, -0.5  
 -0.5, -0.5

دھنے پس بی اولیہ

0.5

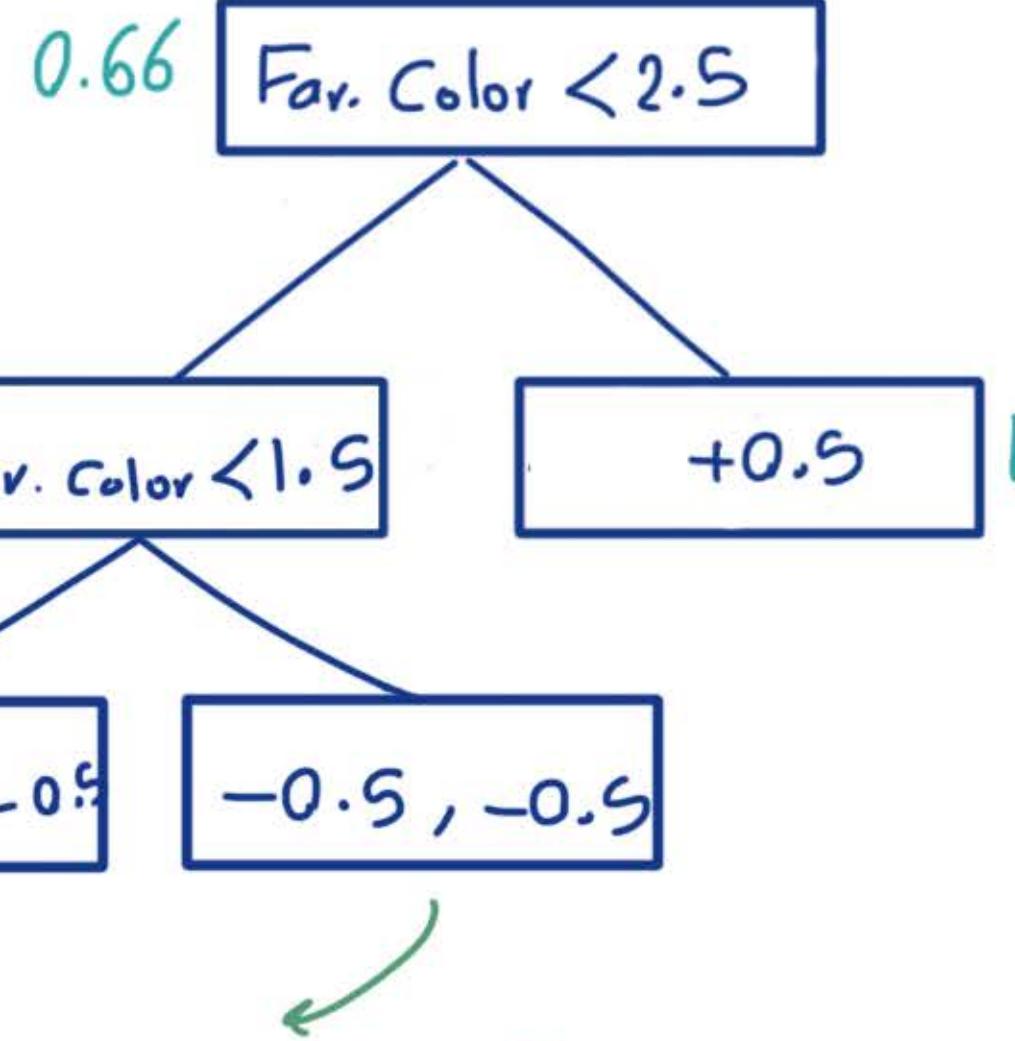
$$\text{Sim Score} = \frac{(-0.5 + 0.5 - 0.5)^2}{3 \times 0.25} = 0.33$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

دھنے پس بی اولیہ

0.5

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5



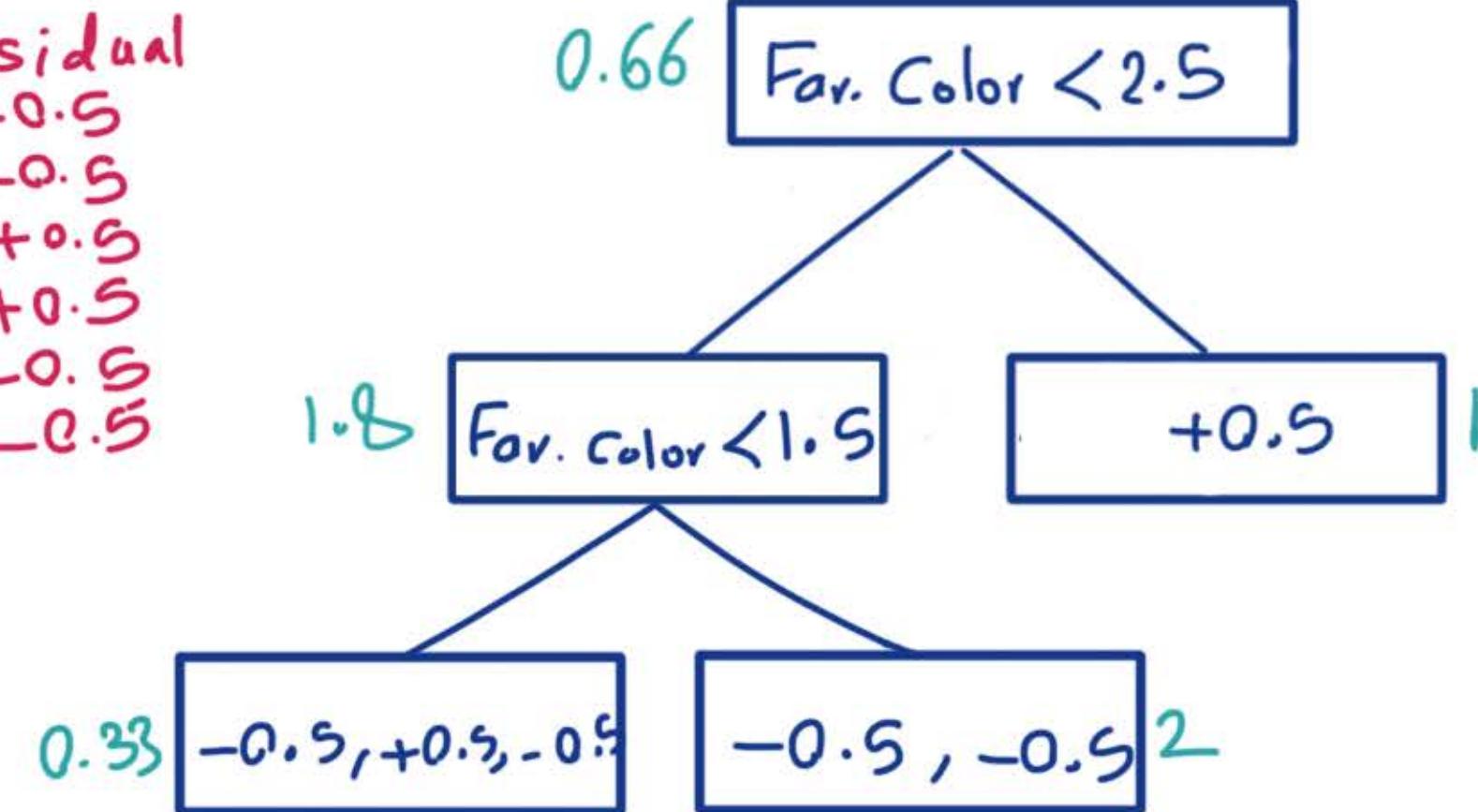
$$\text{Sim. Score} = \frac{(-0.5 - 0.5)^2}{2 \times 0.25} = 2$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

دھنے پس بی اولیہ

0.5

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5



$$Gain = 2 + 0.33 - 1.8 = 0.53$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

0.66  
 Far. Color < 2.5

1.8

Age < 38

+0.5

3

-0.5,-0.5,-0.5

-0.5,+0.5

0

دخت نیس بسی اولیہ

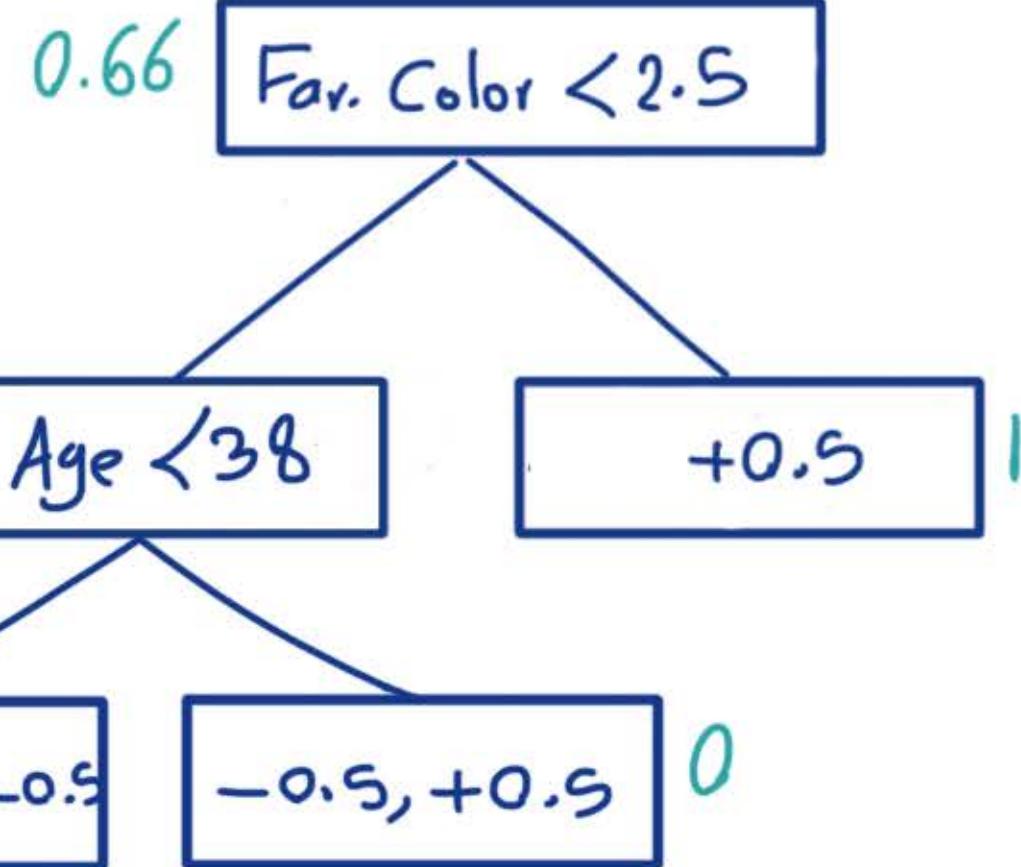
0.5

دس بسترن Gain روی این دخت بست جاید. حال اگر فرم  
 کنیم حداقل همچ مجاز دخت برابر ۲ باشد، تار ساخت این دخت ب-

ذایان فیلم و با یه دخت جدید بسازیم.

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5



دخت نیس بسی اولیه

0.5

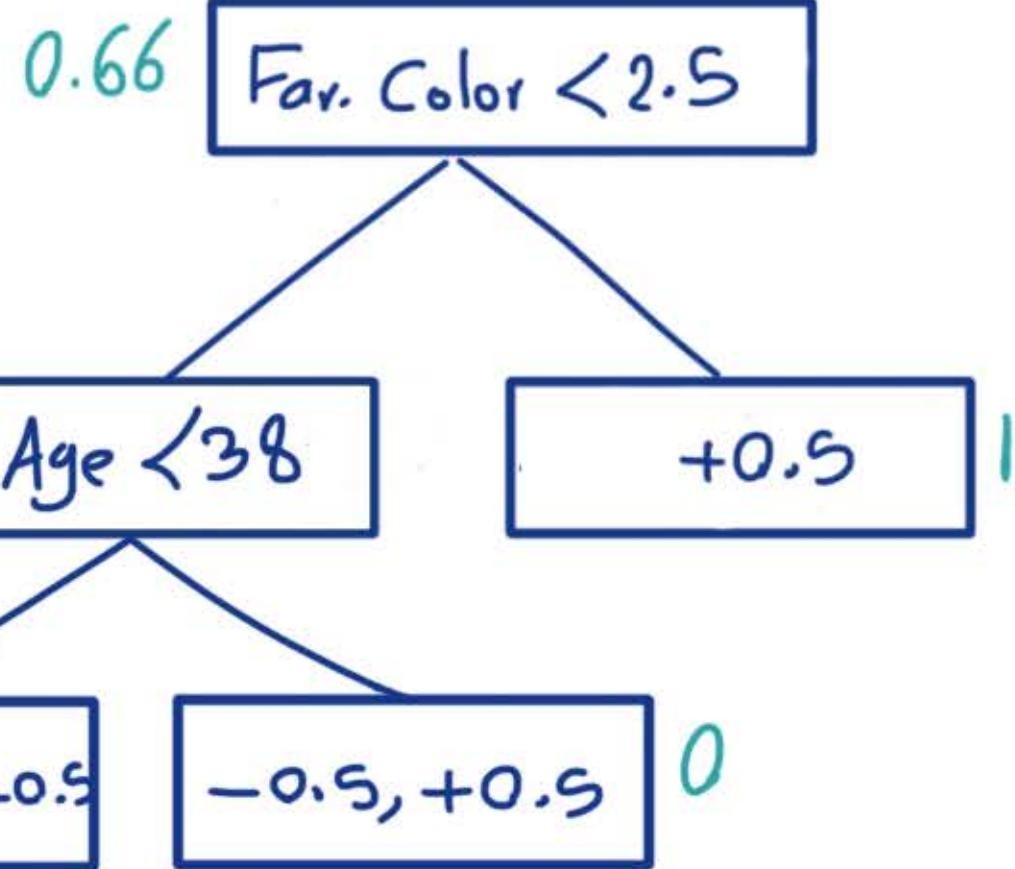
$y - \hat{y}$  از اول residual نهادن باشد  
 حگر قسم های علاوه ت شناسی نبود

قبل از آن هی دلیل output هر برد دخت بر لبراست با :

$$\frac{-\sum (\text{Residual}_i)}{\sum [\text{Previous Prob.}_i \times (1 - \text{Previous Prob.}_i)] + \lambda}$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5



دخت لیس بسی اولیه

0.5

پس خودمی بگ همی دخت را حواس می کنیم تا از آن برای  
 دسته بندی استفاده کنیم.

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

0.66

Far. Color < 2.5

1.8

Age < 38

+0.5

3

-0.5, -0.5, -0.5

-0.5, +0.5

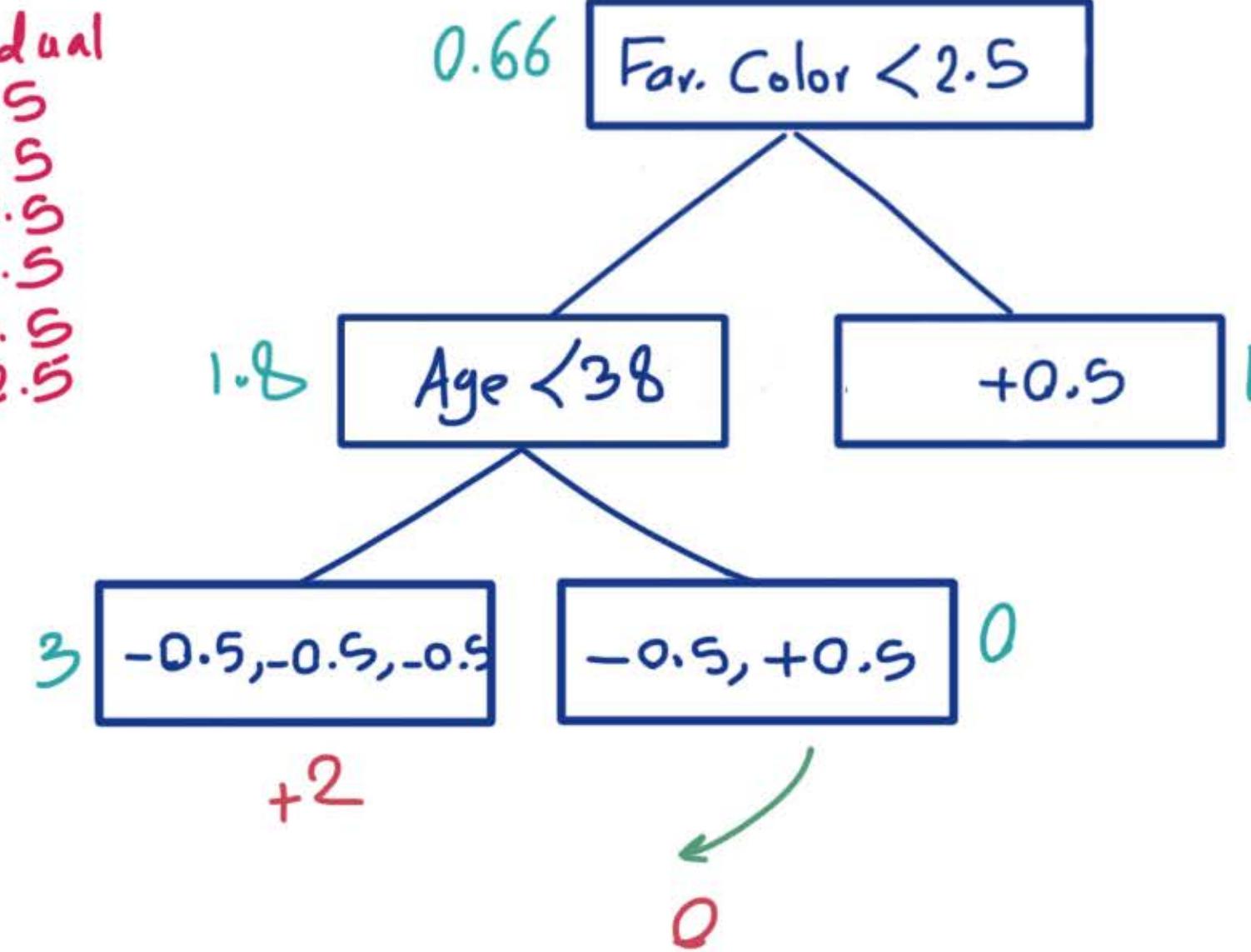
0

دھنے پس بی اولیہ  
 0.5

$$-\frac{-1.5}{3 \times 0.25} = +2$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5

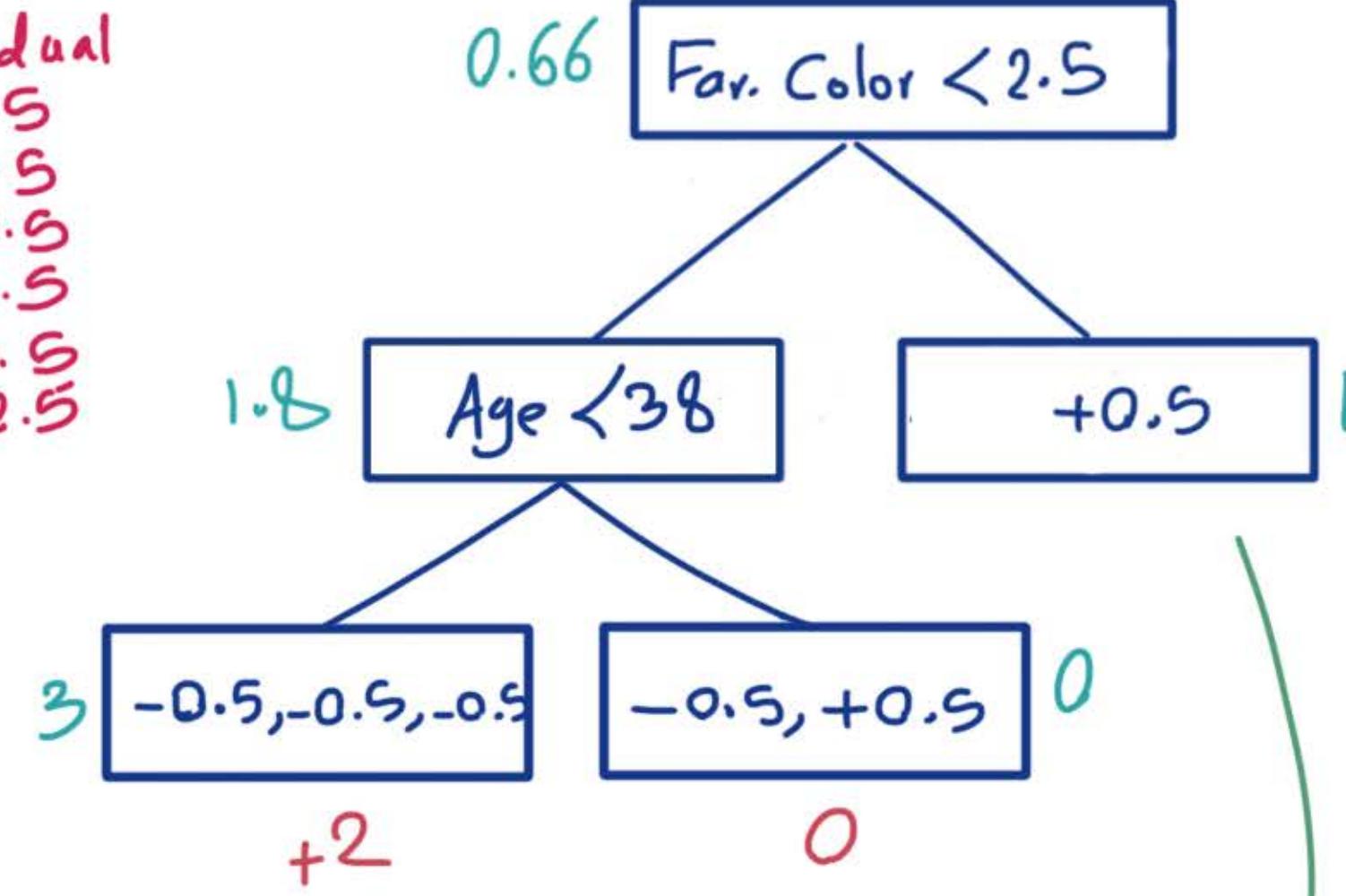


دھنے پس بی اولیہ

0.5

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5



دھنے پس بی اولیہ

0.5

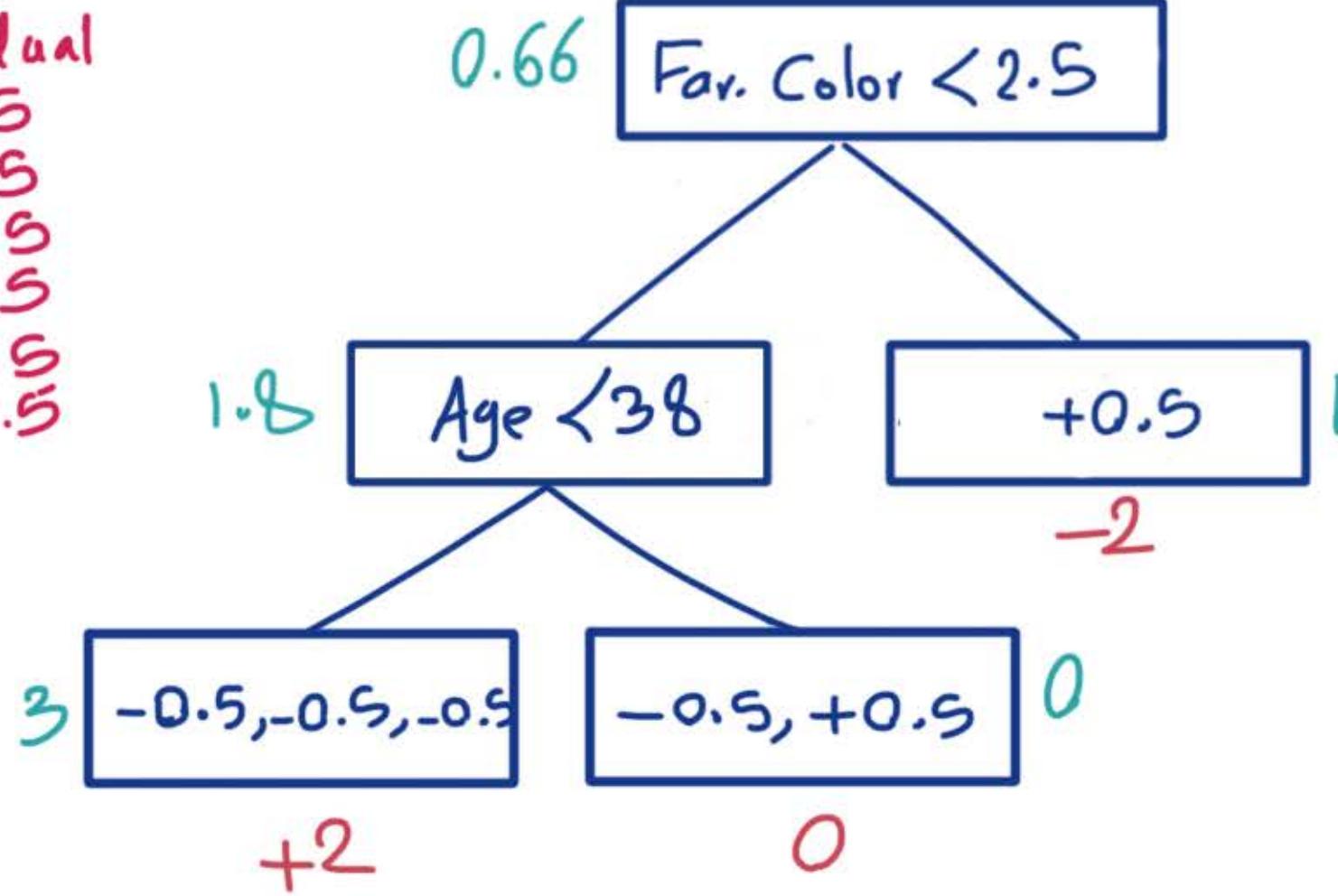
$$-2 = \frac{-0.5}{0.25}$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 |
|---------------|-----|----------------|---------------|
| 1             | 12  | 1              | 1             |
| 1             | 87  | 2              | 1             |
| 0             | 44  | 1              | 0             |
| 1             | 19  | 3              | 0             |
| 0             | 32  | 2              | 1             |
| 0             | 14  | 1              | 1             |

دھنٰت لیس سی اولیے

0.5

Residual  
 -0.5  
 -0.5  
 +0.5  
 +0.5  
 -0.5  
 -0.5



کس خندوچی د بگھلی دھنٰت ب شکل بالا ھی باو.

به شکل پسی فرضی برای دسته نهایی ترکیب learning rate، XGBoost ایگر پیش بینی

اچمال Yes بودن خروجی برای مدل داده تا لمحه  $t-1$  با  $P_{t-1}(x)$  غایی داشتم و خروجی درخت لذتی  $(f_t)$  به

از ای داده  $x$  را تغییر  $f_t(x)$  غایی داشتم، اچمال جدید به ای  $x$  از این رابطه محاسبه می شود:

$$P_t(x) = \sigma \left( \log \left( \frac{P_{t-1}(x)}{1 - P_{t-1}(x)} \right) + f_t(x) \right)$$

ک

$$\sigma(x) = \frac{e^x}{1 + e^x}$$

طبق این رابطه اچمال بعد از هر داده دستاورد کلاس ۱ را محاسبه می کنیم.

| <i>Likes Popcorn</i> | <i>Age</i> | <i>Favorite Color</i> | <i>Loves Troll 2</i> |
|----------------------|------------|-----------------------|----------------------|
| 1                    | 12         | 1                     | 1                    |
| 1                    | 87         | 2                     | 1                    |
| 0                    | 44         | 1                     | 0                    |
| 1                    | 19         | 3                     | 0                    |
| 0                    | 32         | 2                     | 1                    |
| 0                    | 14         | 1                     | 1                    |

$$\rightarrow \sigma\left(\log\left(\frac{0.5}{1-0.5}\right) + 0.3 \times 2\right) = 0.65$$

$$\rightarrow \sigma\left(\log\left(\frac{0.5}{1-0.5}\right) + 0.3 \times 0\right) = 0.5$$

$$\rightarrow \sigma\left(\log\left(\frac{0.5}{1-0.5}\right) + 0.3 \times 0\right) = 0.5$$

$$\rightarrow \sigma\left(\log\left(\frac{0.5}{1-0.5}\right) + 0.3 \times -2\right) = 0.35$$

$$\rightarrow \sigma\left(\log\left(\frac{0.5}{1-0.5}\right) + 0.3 \times 2\right) = 0.65$$

$$\rightarrow \sigma\left(\log\left(\frac{0.5}{1-0.5}\right) + 0.3 \times 2\right) = 0.65$$

همانطورکه مُتّاهده می شود از پیش بینی 0.5 بست برعیب هر داده حکمت کرده ایم و خطا را کا هس داده ایم. با ادای این روند داده هایی که هنوز خوب دست نبیش شده اند بدستی قربو طه نزد ملیر خواهد شد.

برای اینکار ابتدا امثال معابه شده هر داده به همراه در جدول قرار می گیرد.

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 | Prob | Res.  |
|---------------|-----|----------------|---------------|------|-------|
| 1             | 12  | 1              | 1             | 0.65 | -0.35 |
| 1             | 87  | 2              | 1             | 0.5  | -0.5  |
| 0             | 44  | 1              | 0             | 0.5  | +0.5  |
| 1             | 19  | 3              | 0             | 0.35 | +0.35 |
| 0             | 32  | 2              | 1             | 0.65 | -0.35 |
| 0             | 14  | 1              | 1             | 0.65 | -0.35 |

حل مجدداً مقادیر Residual را کم بگردد  
Similarity Score و  $\text{sim}$  را محاسبه می‌کنیم.

$-0.35, -0.5, +0.5, +0.35, -0.35, -0.35$

$$\text{sim score} = \frac{(-0.35 - 0.5 + 0.5 + 0.35 - 0.35 - 0.35)^2}{3 \times (0.65)(0.35) + 2(0.5)(0.5) + (0.35)(0.65)}$$

$$= \frac{0.49}{1.41} = \underline{\underline{0.34}}$$

| Likes Popcorn | Age | Favorite Color | Loves Troll 2 | Prob | Ros.  |
|---------------|-----|----------------|---------------|------|-------|
| 1             | 12  | 1              | 1             | 0.65 | -0.35 |
| 1             | 87  | 2              | 1             | 0.5  | -0.5  |
| 0             | 44  | 1              | 0             | 0.5  | +0.5  |
| 1             | 19  | 3              | 0             | 0.35 | +0.35 |
| 0             | 32  | 2              | 1             | 0.65 | -0.35 |
| 0             | 14  | 1              | 1             | 0.65 | -0.35 |

ب همین ترتیب بعد از همین Split های میان را به اسکرین و مقایسه با مواردی که لفته بود

درخت جدیدی را حی سازیم. از آنجایی که boost خوبی را داشت هر قدر نه می خواهیم ادامه داشته باشد و

امکان تکرار میان موارد تا این وجود ندارد، همینجا کار را متوقف می کنیم. مرحله الگوریتم به طور

قابل توضیح دارد و شرح می شود.