1.

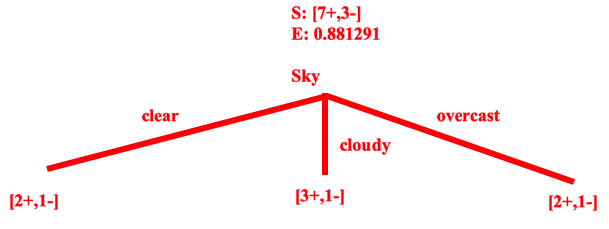
a.

S = {7 yes(+), 3 no(-)}

Total = 10

Entropy(S) = 0.881291

b.



Entropy(S) = 0.881291

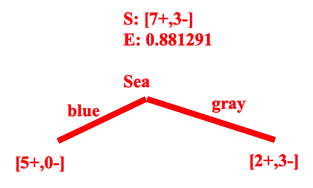
Entropy(Sclear) =

Entropy(Scloudy) =

Entropy(Sovercast) =

Information gain using Sky as root = 0.005802

c.

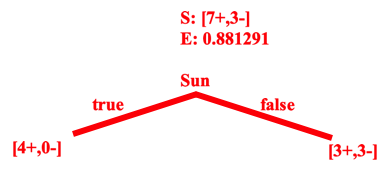


Entropy(Sblue) =

Entropy(Sgray) =

Information gain using Sea as root = 0.395816

d.

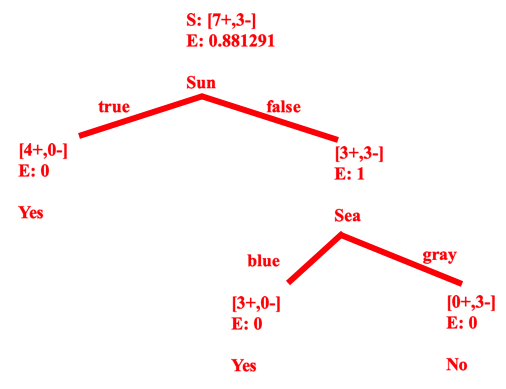


Entropy(Strue) =

Entropy(Sfalse) =

Information gain using Sun as root = 0.881291

e.



f.

Sail = yes

2.

a.

|  |  |  |  |
| --- | --- | --- | --- |
| Sky | Sea | Sun | Sail |
| 1 | 1 | 1 | 1 |
| 1 | 2 | 2 | 1 |
| 1 | 2 | 1 | 0 |
| 2 | 1 | 2 | 1 |
| 2 | 1 | 1 | 1 |
| 2 | 2 | 2 | 1 |
| 2 | 2 | 1 | 0 |
| 3 | 1 | 2 | 1 |
| 3 | 1 | 1 | 1 |
| 3 | 2 | 1 | 0 |

b.

Initial weights: <1.0, 1.0, 1.0, 1.0>

Update rule:

wi <- wi + α(y – hw(X) ) \* xi

where hw(X) = {1 if w.x ≥ 0

{0 otherwise

pass: 1

weight 1 : [1.0, 1.0, 1.0, 1.0]

h 1 ( [1.0, 1.0, 1.0, 1.0] ) = [1.0, 1.0, 1.0, 1.0] \* [1.0, 1.0, 1.0, 1.0] = 4.0 = 1.0

weight 2 = [1.0, 1.0, 1.0, 1.0] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 1.0, 1.0, 1.0] = [1.0, 1.0, 1.0, 1.0]

no update

weight 2 : [1.0, 1.0, 1.0, 1.0]

h 2 ( [1.0, 1.0, 2.0, 2.0] ) = [1.0, 1.0, 1.0, 1.0] \* [1.0, 1.0, 2.0, 2.0] = 6.0 = 1.0

weight 3 = [1.0, 1.0, 1.0, 1.0] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 1.0, 2.0, 2.0] = [1.0, 1.0, 1.0, 1.0]

no update

weight 3 : [1.0, 1.0, 1.0, 1.0]

h 3 ( [1.0, 1.0, 2.0, 1.0] ) = [1.0, 1.0, 1.0, 1.0] \* [1.0, 1.0, 2.0, 1.0] = 5.0 = 1.0

weight 4 = [1.0, 1.0, 1.0, 1.0] + 0.5 \* ( 0.0 - 1.0 ) \* [1.0, 1.0, 2.0, 1.0] = [0.5, 0.5, 0.0, 0.5]

updated

weight 4 : [0.5, 0.5, 0.0, 0.5]

h 4 ( [1.0, 2.0, 1.0, 2.0] ) = [0.5, 0.5, 0.0, 0.5] \* [1.0, 2.0, 1.0, 2.0] = 2.5 = 1.0

weight 5 = [0.5, 0.5, 0.0, 0.5] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 2.0, 1.0, 2.0] = [0.5, 0.5, 0.0, 0.5]

no update

weight 5 : [0.5, 0.5, 0.0, 0.5]

h 5 ( [1.0, 2.0, 1.0, 1.0] ) = [0.5, 0.5, 0.0, 0.5] \* [1.0, 2.0, 1.0, 1.0] = 2.0 = 1.0

weight 6 = [0.5, 0.5, 0.0, 0.5] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 2.0, 1.0, 1.0] = [0.5, 0.5, 0.0, 0.5]

no update

weight 6 : [0.5, 0.5, 0.0, 0.5]

h 6 ( [1.0, 2.0, 2.0, 2.0] ) = [0.5, 0.5, 0.0, 0.5] \* [1.0, 2.0, 2.0, 2.0] = 2.5 = 1.0

weight 7 = [0.5, 0.5, 0.0, 0.5] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 2.0, 2.0, 2.0] = [0.5, 0.5, 0.0, 0.5]

no update

weight 7 : [0.5, 0.5, 0.0, 0.5]

h 7 ( [1.0, 2.0, 2.0, 1.0] ) = [0.5, 0.5, 0.0, 0.5] \* [1.0, 2.0, 2.0, 1.0] = 2.0 = 1.0

weight 8 = [0.5, 0.5, 0.0, 0.5] + 0.5 \* ( 0.0 - 1.0 ) \* [1.0, 2.0, 2.0, 1.0] = [0.0, -0.5, -1.0, 0.0]

updated

weight 8 : [0.0, -0.5, -1.0, 0.0]

h 8 ( [1.0, 3.0, 1.0, 2.0] ) = [0.0, -0.5, -1.0, 0.0] \* [1.0, 3.0, 1.0, 2.0] = -2.5 = 0.0

weight 9 = [0.0, -0.5, -1.0, 0.0] + 0.5 \* ( 1.0 - 0.0 ) \* [1.0, 3.0, 1.0, 2.0] = [0.5, 1.0, -0.5, 1.0]

updated

weight 9 : [0.5, 1.0, -0.5, 1.0]

h 9 ( [1.0, 3.0, 1.0, 1.0] ) = [0.5, 1.0, -0.5, 1.0] \* [1.0, 3.0, 1.0, 1.0] = 4.0 = 1.0

weight 10 = [0.5, 1.0, -0.5, 1.0] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 3.0, 1.0, 1.0] = [0.5, 1.0, -0.5, 1.0]

no update

weight 10 : [0.5, 1.0, -0.5, 1.0]

h 10 ( [1.0, 3.0, 2.0, 1.0] ) = [0.5, 1.0, -0.5, 1.0] \* [1.0, 3.0, 2.0, 1.0] = 3.5 = 1.0

weight 11 = [0.5, 1.0, -0.5, 1.0] + 0.5 \* ( 0.0 - 1.0 ) \* [1.0, 3.0, 2.0, 1.0] = [0.0, -0.5, -1.5, 0.5]

updated

pass: 2

weight 11 : [0.0, -0.5, -1.5, 0.5]

h 1 ( [1.0, 1.0, 1.0, 1.0] ) = [0.0, -0.5, -1.5, 0.5] \* [1.0, 1.0, 1.0, 1.0] = -1.5 = 0.0

weight 12 = [0.0, -0.5, -1.5, 0.5] + 0.5 \* ( 1.0 - 0.0 ) \* [1.0, 1.0, 1.0, 1.0] = [0.5, 0.0, -1.0, 1.0]

updated

weight 12 : [0.5, 0.0, -1.0, 1.0]

h 2 ( [1.0, 1.0, 2.0, 2.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 1.0, 2.0, 2.0] = 0.5 = 1.0

weight 13 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 1.0, 2.0, 2.0] = [0.5, 0.0, -1.0, 1.0]

no update

weight 13 : [0.5, 0.0, -1.0, 1.0]

h 3 ( [1.0, 1.0, 2.0, 1.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 1.0, 2.0, 1.0] = -0.5 = 0.0

weight 14 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 0.0 - 0.0 ) \* [1.0, 1.0, 2.0, 1.0] = [0.5, 0.0, -1.0, 1.0]

no update

weight 14 : [0.5, 0.0, -1.0, 1.0]

h 4 ( [1.0, 2.0, 1.0, 2.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 2.0, 1.0, 2.0] = 1.5 = 1.0

weight 15 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 2.0, 1.0, 2.0] = [0.5, 0.0, -1.0, 1.0]

no update

weight 15 : [0.5, 0.0, -1.0, 1.0]

h 5 ( [1.0, 2.0, 1.0, 1.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 2.0, 1.0, 1.0] = 0.5 = 1.0

weight 16 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 2.0, 1.0, 1.0] = [0.5, 0.0, -1.0, 1.0]

no update

weight 16 : [0.5, 0.0, -1.0, 1.0]

h 6 ( [1.0, 2.0, 2.0, 2.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 2.0, 2.0, 2.0] = 0.5 = 1.0

weight 17 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 2.0, 2.0, 2.0] = [0.5, 0.0, -1.0, 1.0]

no update

weight 17 : [0.5, 0.0, -1.0, 1.0]

h 7 ( [1.0, 2.0, 2.0, 1.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 2.0, 2.0, 1.0] = -0.5 = 0.0

weight 18 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 0.0 - 0.0 ) \* [1.0, 2.0, 2.0, 1.0] = [0.5, 0.0, -1.0, 1.0]

no update

weight 18 : [0.5, 0.0, -1.0, 1.0]

h 8 ( [1.0, 3.0, 1.0, 2.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 3.0, 1.0, 2.0] = 1.5 = 1.0

weight 19 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 3.0, 1.0, 2.0] = [0.5, 0.0, -1.0, 1.0]

no update

weight 19 : [0.5, 0.0, -1.0, 1.0]

h 9 ( [1.0, 3.0, 1.0, 1.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 3.0, 1.0, 1.0] = 0.5 = 1.0

weight 20 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 3.0, 1.0, 1.0] = [0.5, 0.0, -1.0, 1.0]

no update

weight 20 : [0.5, 0.0, -1.0, 1.0]

h 10 ( [1.0, 3.0, 2.0, 1.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 3.0, 2.0, 1.0] = -0.5 = 0.0

weight 21 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 0.0 - 0.0 ) \* [1.0, 3.0, 2.0, 1.0] = [0.5, 0.0, -1.0, 1.0]

no update

pass: 3

weight 21 : [0.5, 0.0, -1.0, 1.0]

h 1 ( [1.0, 1.0, 1.0, 1.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 1.0, 1.0, 1.0] = 0.5 = 1.0

weight 22 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 1.0, 1.0, 1.0] = [0.5, 0.0, -1.0, 1.0]

no update

weight 22 : [0.5, 0.0, -1.0, 1.0]

h 2 ( [1.0, 1.0, 2.0, 2.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 1.0, 2.0, 2.0] = 0.5 = 1.0

weight 23 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 1.0, 2.0, 2.0] = [0.5, 0.0, -1.0, 1.0]

no update

weight 23 : [0.5, 0.0, -1.0, 1.0]

h 3 ( [1.0, 1.0, 2.0, 1.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 1.0, 2.0, 1.0] = -0.5 = 0.0

weight 24 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 0.0 - 0.0 ) \* [1.0, 1.0, 2.0, 1.0] = [0.5, 0.0, -1.0, 1.0]

no update

weight 24 : [0.5, 0.0, -1.0, 1.0]

h 4 ( [1.0, 2.0, 1.0, 2.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 2.0, 1.0, 2.0] = 1.5 = 1.0

weight 25 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 2.0, 1.0, 2.0] = [0.5, 0.0, -1.0, 1.0]

no update

weight 25 : [0.5, 0.0, -1.0, 1.0]

h 5 ( [1.0, 2.0, 1.0, 1.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 2.0, 1.0, 1.0] = 0.5 = 1.0

weight 26 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 2.0, 1.0, 1.0] = [0.5, 0.0, -1.0, 1.0]

no update

weight 26 : [0.5, 0.0, -1.0, 1.0]

h 6 ( [1.0, 2.0, 2.0, 2.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 2.0, 2.0, 2.0] = 0.5 = 1.0

weight 27 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 2.0, 2.0, 2.0] = [0.5, 0.0, -1.0, 1.0]

no update

weight 27 : [0.5, 0.0, -1.0, 1.0]

h 7 ( [1.0, 2.0, 2.0, 1.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 2.0, 2.0, 1.0] = -0.5 = 0.0

weight 28 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 0.0 - 0.0 ) \* [1.0, 2.0, 2.0, 1.0] = [0.5, 0.0, -1.0, 1.0]

no update

weight 28 : [0.5, 0.0, -1.0, 1.0]

h 8 ( [1.0, 3.0, 1.0, 2.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 3.0, 1.0, 2.0] = 1.5 = 1.0

weight 29 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 3.0, 1.0, 2.0] = [0.5, 0.0, -1.0, 1.0]

no update

weight 29 : [0.5, 0.0, -1.0, 1.0]

h 9 ( [1.0, 3.0, 1.0, 1.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 3.0, 1.0, 1.0] = 0.5 = 1.0

weight 30 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 1.0 - 1.0 ) \* [1.0, 3.0, 1.0, 1.0] = [0.5, 0.0, -1.0, 1.0]

no update

weight 30 : [0.5, 0.0, -1.0, 1.0]

h 10 ( [1.0, 3.0, 2.0, 1.0] ) = [0.5, 0.0, -1.0, 1.0] \* [1.0, 3.0, 2.0, 1.0] = -0.5 = 0.0

weight 31 = [0.5, 0.0, -1.0, 1.0] + 0.5 \* ( 0.0 - 0.0 ) \* [1.0, 3.0, 2.0, 1.0] = [0.5, 0.0, -1.0, 1.0]

no update

c.

<Sky=overcast, Sea=gray, Sun=true> = (3.0, 2.0, 2.0) => (1.0, 3.0, 2.0, 2.0)

weight = (0.5, 0.0, -1.0, 1.0)

classification: hw(X) = {1 if w.x ≥ 0

{0 otherwise

w.x = (0.5, 0.0, -1.0, 1.0) . (1.0, 3.0, 2.0, 2.0) = 0.5 + 0 + (-2.0) + (2.0) = 0.5

0.5 ≥ 0 therefore the classification is 1 which is sail = yes.

The learned perceptron will classify <Sky=overcast, Sea=gray, Sun=true> as sail = yes.