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Data Analytics

Problem 2

Decision Trees: ID3 Algorithm

Dataset:

ID	Fever	Cough	Breathing Issues	Infected
1	No	No	No	No
2	Yes	Yes	Yes	Yes
3	Yes	Yes	No	No
4	Yes	No	Yes	Yes
5	Yes	Yes	Yes	Yes
6	No	Yes	No	No
7	Yes	No	Yes	Yes
8	Yes	No	Yes	Yes
9	No	Yes	Yes	Yes
10	Yes	Yes	No	Yes
11	No	Yes	No	No
12	No	Yes	Yes	Yes
13	No	Yes	Yes	No
14	Yes	Yes	No	No

Infected attribute will be used as Decision factor

P = 8

N = 6

Total = 14

$$Entropy = \frac{-p}{p+n} log_2(\frac{p}{p+n}) - \frac{n}{p+n} log_2(\frac{n}{p+n})$$

Dataset (Entropy) = ((-P/(P+N)*(LOG((P/(P+N)),2)))-((N/(P+N))*(LOG((N/(P+N)),2))))

Dataset (Entropy) = 0.985228

Now calculating Entropy for Fever Attribute

ID	Fever	Cough	Breathing Issues	Infected
3	Yes	No	No	No
14	Yes	No	No	No
2	Yes	Yes	Yes	Yes
4	Yes	Yes	Yes	Yes
5	Yes	Yes	Yes	Yes
7	Yes	Yes	Yes	Yes
8	Yes	Yes	Yes	Yes
10	Yes	No	No	Yes

ID	Fever	Cough	Breathing Issues	Infected
1	No	No	No	No
6	No	No	No	No
11	No	No	No	No
13	No	Yes	Yes	No
9	No	Yes	Yes	Yes
12	No	Yes	Yes	Yes

Fever	p	n	Entropy
Yes	6	2	0.811278
No	2	4	0.918296

Average Information Entropy for Fever = 0.8571

Gain (Fever) = 0.128085143

Now calculating Entropy for Cough Attribute

ID	Fever	Cough	Breathing Issues	Infected
2	Yes	Yes	Yes	Yes
3	Yes	Yes	No	No
5	Yes	Yes	Yes	Yes
6	No	Yes	No	No
9	No	Yes	Yes	Yes
10	Yes	Yes	No	Yes
11	No	Yes	No	No
12	No	Yes	Yes	Yes
13	No	Yes	Yes	No
14	Yes	Yes	No	No

ID	Fever	Cough	Breathing Issues	Infected
1	No	No	No	No
4	Yes	No	Yes	Yes
7	Yes	No	Yes	Yes
8	Yes	No	Yes	Yes

Cough	p	n	Entropy
Yes	5	5	1
N	3	1	0.811278

Average Information Entropy = 0.946079464

Gain = 0.039148536

Now calculating Entropy for Breathing Issues Attribute

ID	Fever	Cough	Breathing Issues	Infected
2	Yes	Yes	Yes	Yes
4	Yes	No	Yes	Yes
5	Yes	Yes	Yes	Yes
7	Yes	No	Yes	Yes
8	Yes	No	Yes	Yes
9	No	Yes	Yes	Yes
12	No	Yes	Yes	Yes
13	No	Yes	Yes	No

ID	Fever	Cough	Breathing Issues	Infected
1	No	No	No	No
3	Yes	Yes	No	No
6	No	Yes	No	No
10	Yes	Yes	No	Yes
11	No	Yes	No	No
14	Yes	Yes	No	No

Breathing Issues Attribute	p	n	Entropy
Yes	7	1	0.543564
N	1	5	0.650022

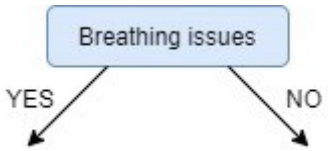
Average Information Entropy	0.589189

Gain	0.396039

Now, after comparing the Gains of each attribute:

Attribute	Gain
Fever	0.128085
Cough	0.039149
Breathing Issues	0.396039

Breathing has the highest gain. Therefore, the root node will be Breathing issues.



Next, from the remaining two unused features, namely, Fever and Cough, we decide which one is the best for the left branch of Breathing Issues. Since the left branch of Breathing Issues denotes YES, we will work with the subset of the original data i.e the set of rows having YES as the value in the Breathing Issues column.

ID	Fever	Cough	Breathing Issues	Infected
2	Yes	Yes	Yes	Yes
4	Yes	No	Yes	Yes
5	Yes	Yes	Yes	Yes
7	Yes	No	Yes	Yes
8	Yes	No	Yes	Yes
9	No	Yes	Yes	Yes
12	No	Yes	Yes	Yes
13	No	Yes	Yes	No

New Entropy for above Subset is 0.543564443

Now Calculating Gain for Cough

ID	Fever	Cough	Breathing Issues	Infected
2	Yes	Yes	Yes	Yes
5	Yes	Yes	Yes	Yes
9	No	Yes	Yes	Yes
12	No	Yes	Yes	Yes
13	No	Yes	Yes	No

Cough	p	n	Entropy
Yes	4	1	0.721928
N	1	0	0

Average Information Entropy	0.451205
Gain	0.092359

Now Calculating Gain for Fever

ID	Fever	Cough	Breathing Issues	Infected
2	Yes	Yes	Yes	Yes
4	Yes	No	Yes	Yes
5	Yes	Yes	Yes	Yes
7	Yes	No	Yes	Yes
8	Yes	No	Yes	Yes

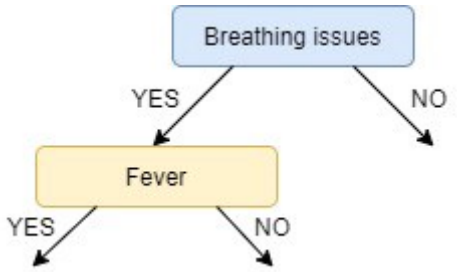
ID	Fever	Cough	Breathing Issues	Infected
9	No	Yes	Yes	Yes
12	No	Yes	Yes	Yes
13	No	Yes	Yes	No

Fever	p	n	Entropy
Yes	1	0	0
N	2	1	0.918296
Average Information Entropy			0.344361
Gain			0.199203

Now comparing gains of Fever and Cough

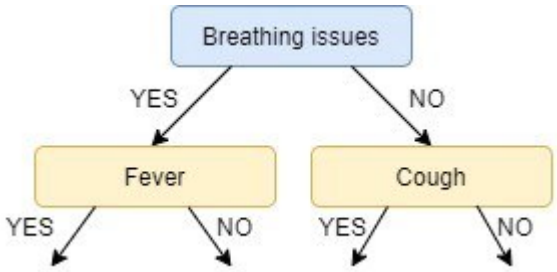
Attribute	Gain
Fever	0.199203
Cough	0.09
Breathing Issues	0.396039

Gain Fever is greater than that of Cough, so we select Fever as the left branch of Breathing Issues:



Next, we find the feature with the maximum IG for the right branch of Breathing Issues. But, since there is only one unused feature left we have no other choice but to make it the right branch of the root node.

So our tree now looks like this:



There are no more unused features, so we stop here and jump to the final step of creating the leaf nodes.

For the left leaf node of Fever, we see the subset of rows from the original data set that has Breathing Issues and Fever both values as YES.

ID	Fever	Cough	Breathing Issues	Infected
2	Yes	Yes	Yes	Yes
4	Yes	No	Yes	Yes
5	Yes	Yes	Yes	Yes
7	Yes	No	Yes	Yes
8	Yes	No	Yes	Yes

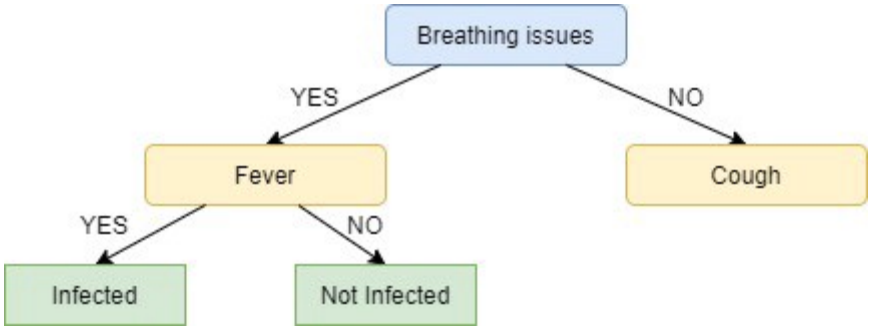
Since all the values in the target column are YES, we label the left leaf node as infected.

Similarly, for the right node of Fever we see the subset of rows from the original data set that have Breathing Issues value as YES and Fever as NO.

ID	Fever	Cough	Breathing Issues	Infected
9	No	Yes	Yes	Yes
12	No	Yes	Yes	Yes
13	No	Yes	Yes	No

Here not all but most of the values are NO, hence Not Infected becomes our right leaf node.

Tree looks like this:

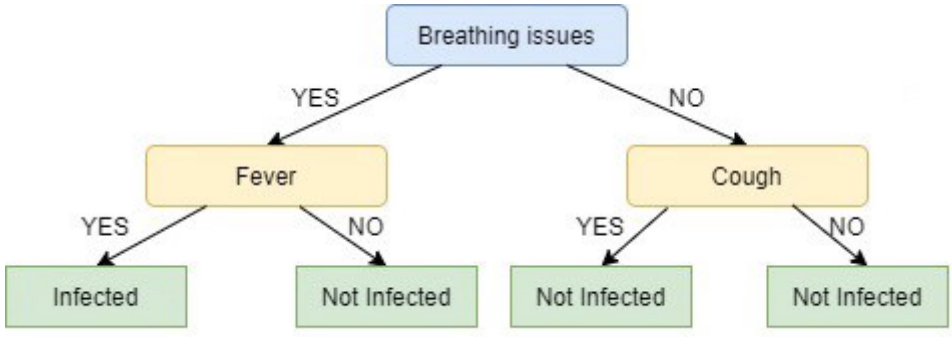


Now, we will repeat the same process for Cough to find out the leaf nodes.

ID	Fever	Cough	Breathing Issues	Infected
1	No	No	No	No

ID	Fever	Cough	Breathing Issues	Infected
3	Yes	Yes	No	No
6	No	Yes	No	No
10	Yes	Yes	No	Yes
11	No	Yes	No	No
14	Yes	Yes	No	No

Since majority of the outcome is n ie. Not infected, the final tree looks like this.



References:

Link - https://towardsdatascience.com/decision-trees-for-classification-id3-algorithm-explained-89df76e72df1

Excel Formulae:

Entropy = = ((-H19/(H19+H20)*(LOG((H19/(H19+H20)),2)))-((H20/(H19+H20))*(LOG((H20/(H19+H20)),2))))

P	H19
N	H20

Average Information Entropy =((((M31+N31)/(J24+J25))*O31)+(((M32+N32)/(J24+J25))*O32))

P	7
N	1

Fever	p	n	Entropy
Yes	1	0	0
N	2	1	0.918296