Introduction to Machine Learning
Program Assignment #1

Problem: (70%)

For this assignment, you need to implement ID3 algorithm to construct a decision tree with C, C++, Java or python2/3, and use K-fold cross validation (K=5) to validate classification performance by outputting precision and recall for each class and total accuracy. You CANNOT use packages to do the jobs for you.

ID3 algorithm

Algorithm 4.1 Pseudocode description of the ID3 algorithm.

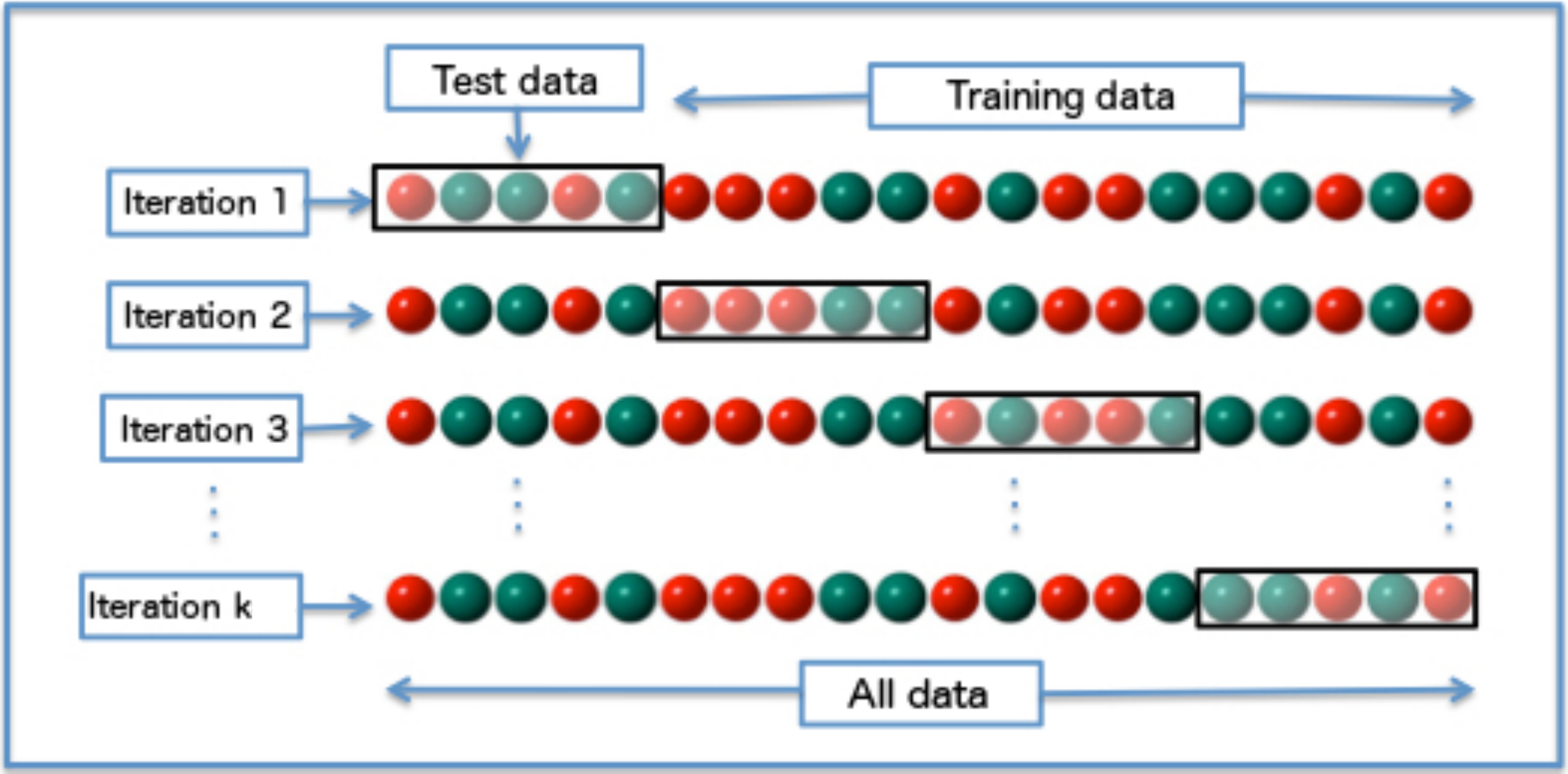
```
Require: set of descriptive features $\mathbf{d}$
Require: set of training instances $\mathcal{D}$
if all the instances in $\mathcal{D}$ have the same target level $C$ then
    return a decision tree consisting of a leaf node with label $C$
```

```
else if $\mathbf{d}$ is empty then
    return a decision tree consisting of a leaf node
    with the label of the majority target level in $\mathcal{D}$
```

```
else if $\mathcal{D}$ is empty then
    return a decision tree consisting
    with the label of the majority
    target level of the dataset of the
    immediate parent node
```

```
else
    $\mathbf{d}[best] \leftarrow \arg\max IG(d, \mathcal{D}) \quad d \in \mathbf{d}$
    partition $\mathcal{D}$ using $\mathbf{d}[best]$
    remove $\mathbf{d}[best]$ from $\mathbf{d}$
    for each partition $\mathcal{D}_i$ of $\mathcal{D}$ do
        grow a branch from $Node_{\mathrm{d}[best]}$
        by rerunning $ID3$ with $\mathcal{D} = \mathcal{D}_i$
```

K - Fold Cross Validation



From wiki - https://en.wikipedia.org/wiki/Cross-validation_(statistics)

After iteration i,

$ACCURACY_i$, $PRECISION_i$, $RECALL_i$ will be obtained.

In this assignment, output the average accuracy, precision and recall:

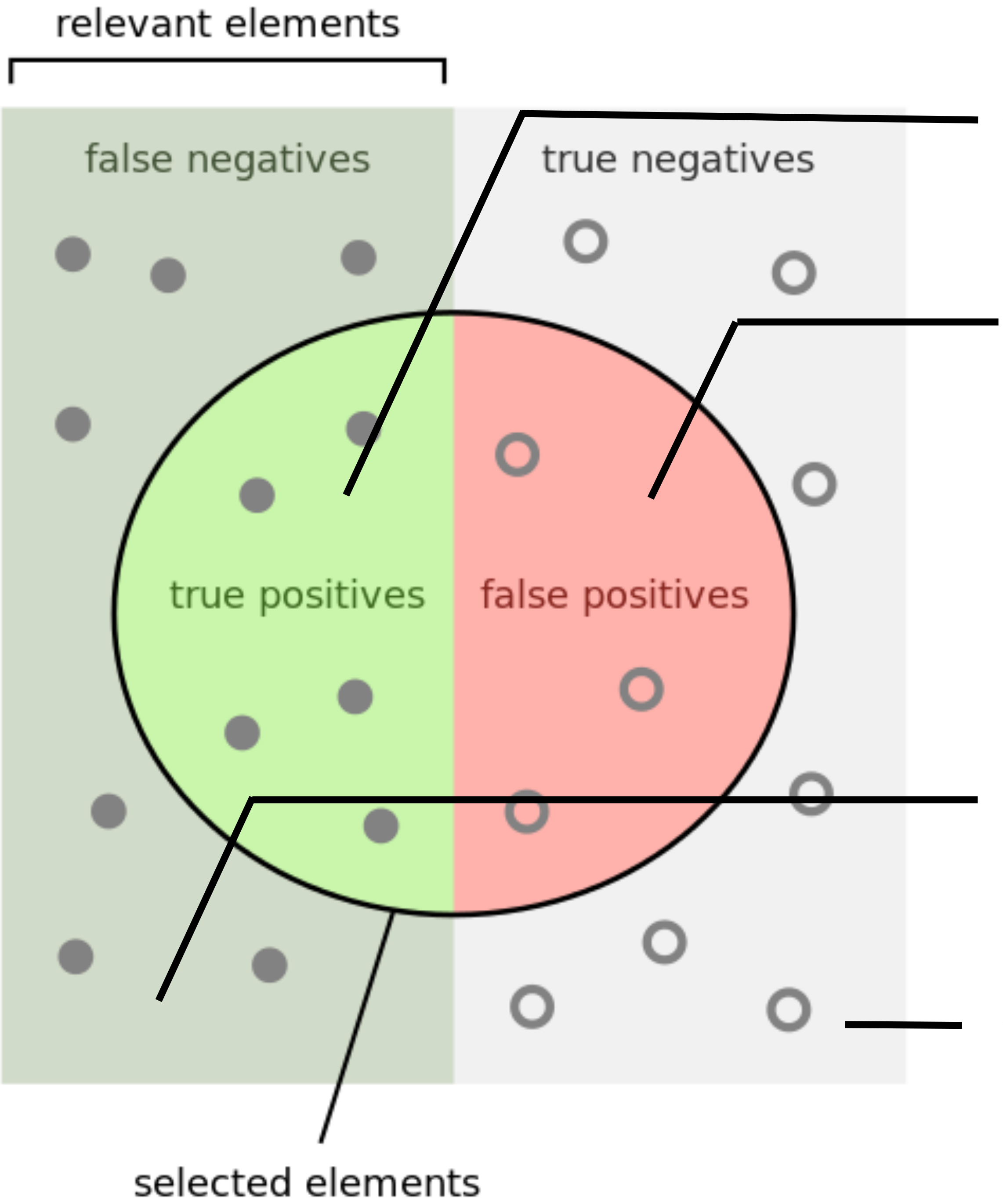
$$ACCURACY_{avg} = \frac{\sum_{i=0}^{K-1} ACCURACY_i}{K}$$

$$PRECISION_{avg} = \frac{\sum_{i=0}^{K-1} PRECISION_i}{K} \qquad RECALL_{avg} = \frac{\sum_{i=0}^{K-1} RECALL_i}{K}$$

$$ACCURACY_i$$

$$PRECISION_i$$

$$RECALL_i$$

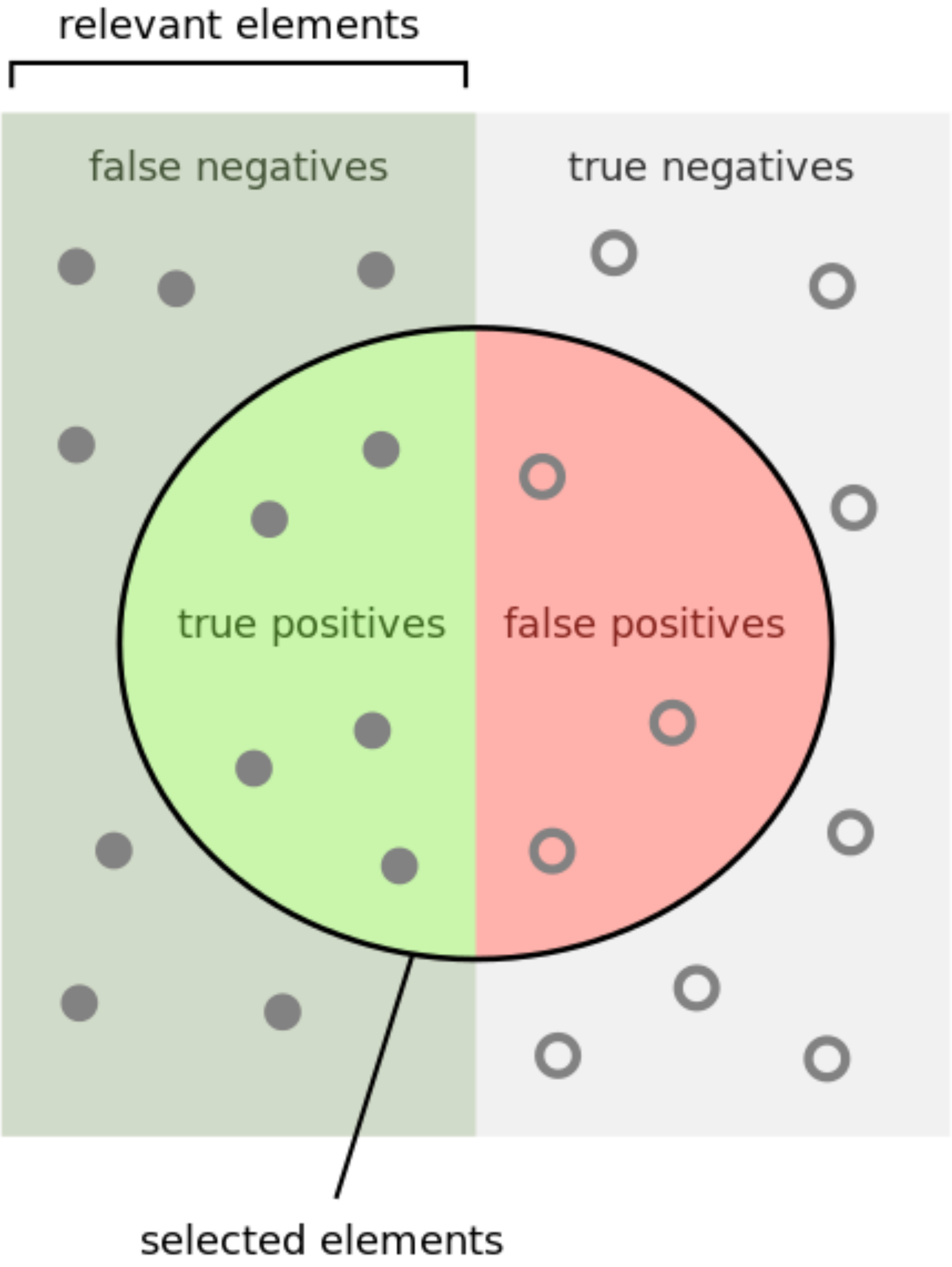


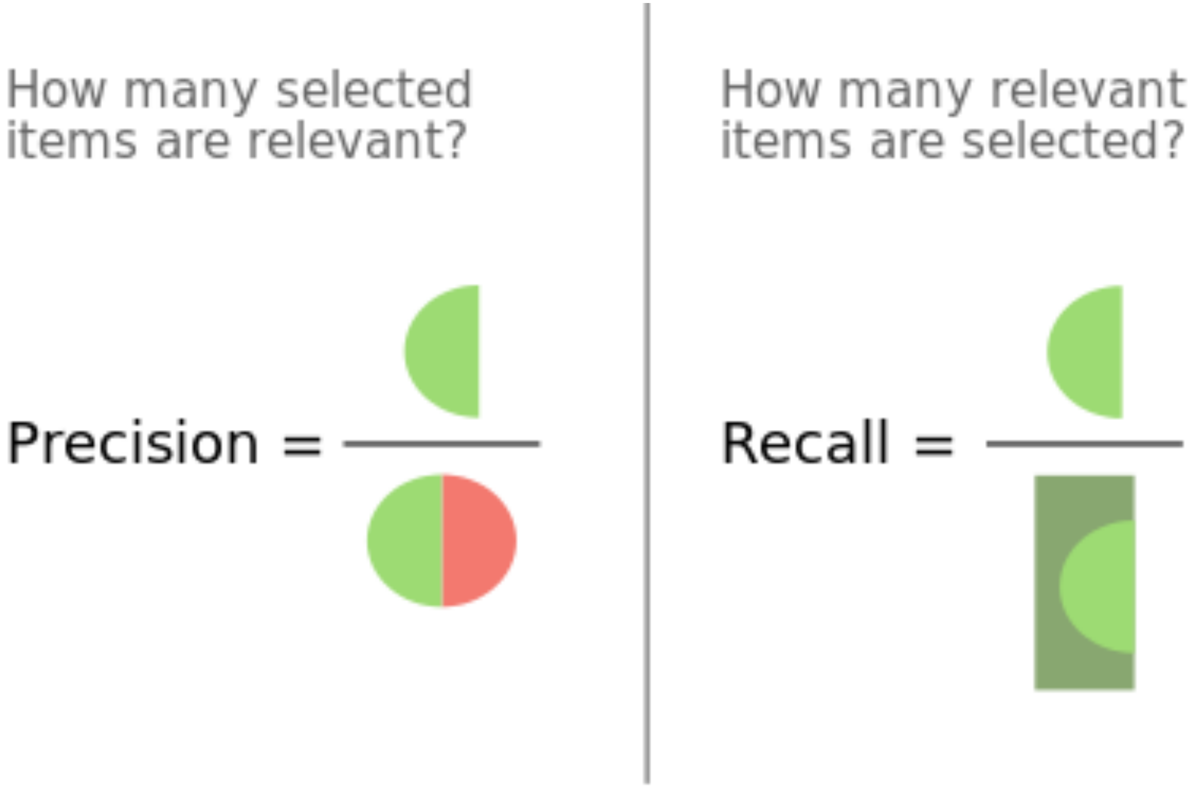
✔ Predict: Yes / Actual: Yes

✖ Predict: Yes / Actual: No

✖ Predict: No / Actual: Yes

✔ Predict: No / Actual: No

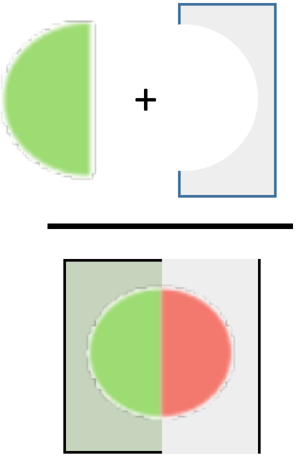



How many selected items are relevant?

Precision =

How many relevant items are selected?

Recall =

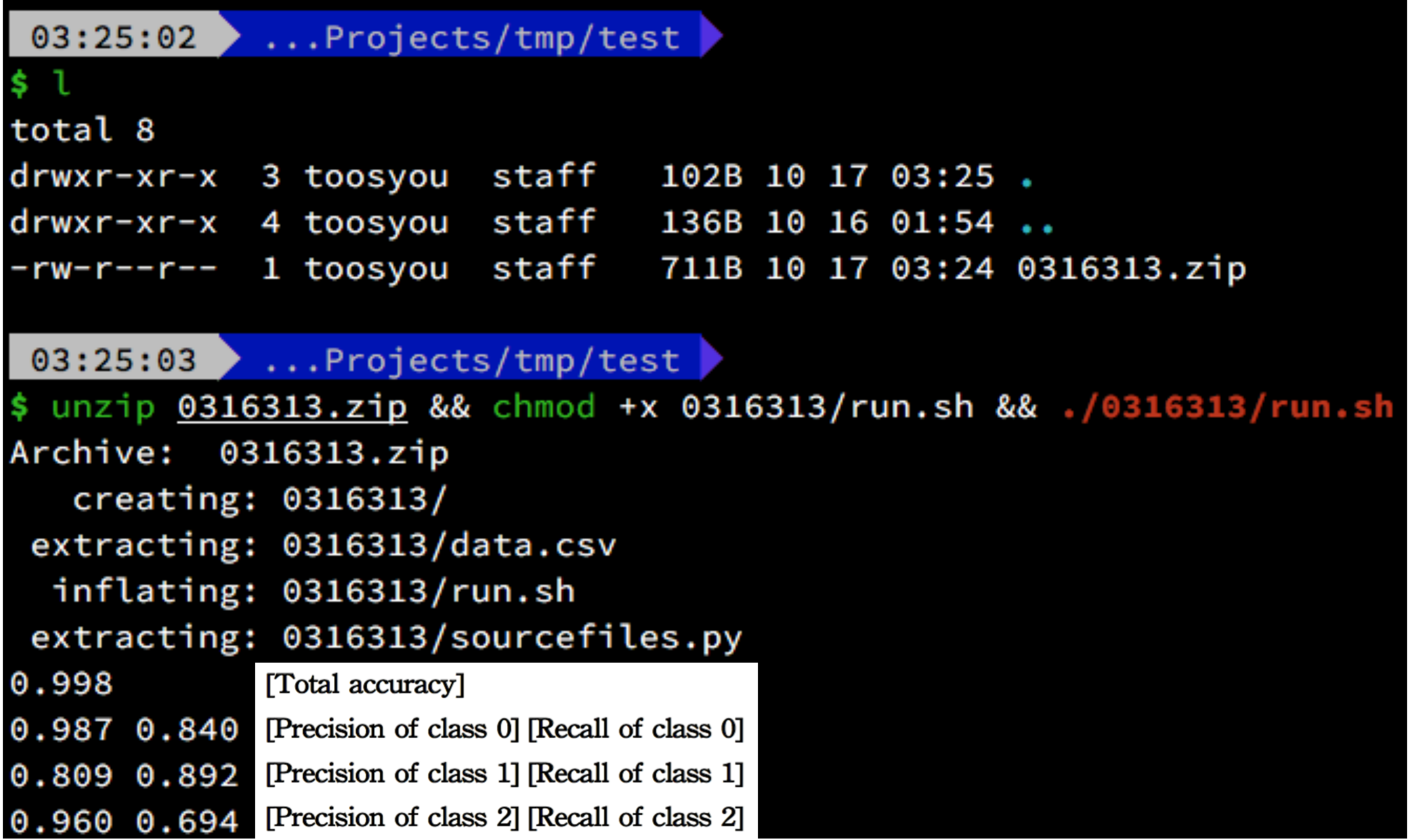


$$Accuracy = \frac{\;\;}{\;\;} = \frac{TP+TN}{TP+FP+FN+TN}$$

You should upload a single [student-id].ZIP file which contains a 'run.sh' shell script, source files, data and a report. The 'run.sh' should compile the source code (for C/C++ and java) and execute the program which output the results by a single './run.sh' command.

Note that, the instances of data must be randomly shuffled before constructing decision trees. The accuracy, precision and recall must be floating numbers within 0 and 1 and be arranged with the following format.

```
[Total accuracy]
[Precision of class 0] [Recall of class 0]
[Precision of class 1] [Recall of class 1]
[Precision of class 2] [Recall of class 2]
```

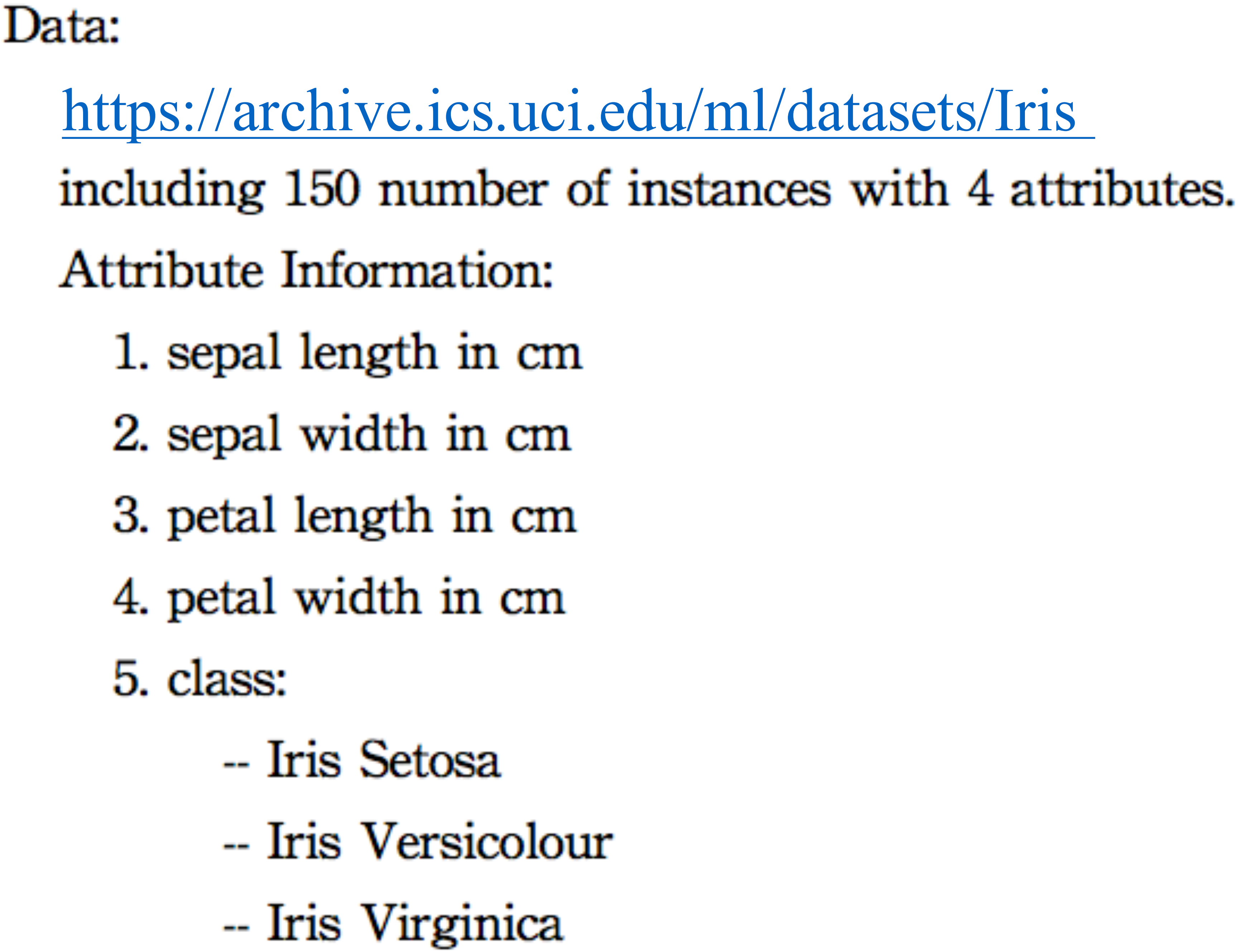


```
 03:25:02  ...Projects/tmp/test
$ l
total 8
drwxr-xr-x  3 toosyou  staff   102B 10 17 03:25 .
drwxr-xr-x  4 toosyou  staff   136B 10 16 01:54 ..
-rw-r--r--  1 toosyou  staff   711B 10 17 03:24 0316313.zip

 03:25:03  ...Projects/tmp/test
$ unzip 0316313.zip && chmod +x 0316313/run.sh && ./0316313/run.sh
Archive:  0316313.zip
   creating: 0316313/
 extracting: 0316313/data.csv
  inflating: 0316313/run.sh
 extracting: 0316313/sourcefiles.py
0.998        [Total accuracy]
0.987 0.840  [Precision of class 0] [Recall of class 0]
0.809 0.892  [Precision of class 1] [Recall of class 1]
0.960 0.694  [Precision of class 2] [Recall of class 2]
```

第十二章、學習 Shell Scripts

http://linux.vbird.org/linux_basic/0340bashshell-scripts.php



Data:

https://archive.ics.uci.edu/ml/datasets/Iris

including 150 number of instances with 4 attributes.

Attribute Information:

1. sepal length in cm
2. sepal width in cm
3. petal length in cm
4. petal width in cm
5. class:
   - -- Iris Setosa
   - -- Iris Versicolour
   - -- Iris Virginica

Handling Continuous Descriptive Features

ID	Stream	Slope	Elevation	Vegetation
1	false	steep	3,900	chapparal
2	true	moderate	300	riparian
3	true	steep	1,500	riparian
4	false	steep	1,200	chapparal
5	false	flat	4,450	conifer
6	true	steep	5,000	conifer
7	true	steep	3,000	chapparal

ID	STREAM	SLOPE	ELEVATION	VEGETATION
2	true	moderate	300	riparian
4	false	steep	1,200	chapparal
3	true	steep	1,500	riparian
7	true	steep	3,000	chapparal
1	false	steep	3,900	chapparal
5	false	flat	4,450	conifer
6	true	steep	5,000	conifer

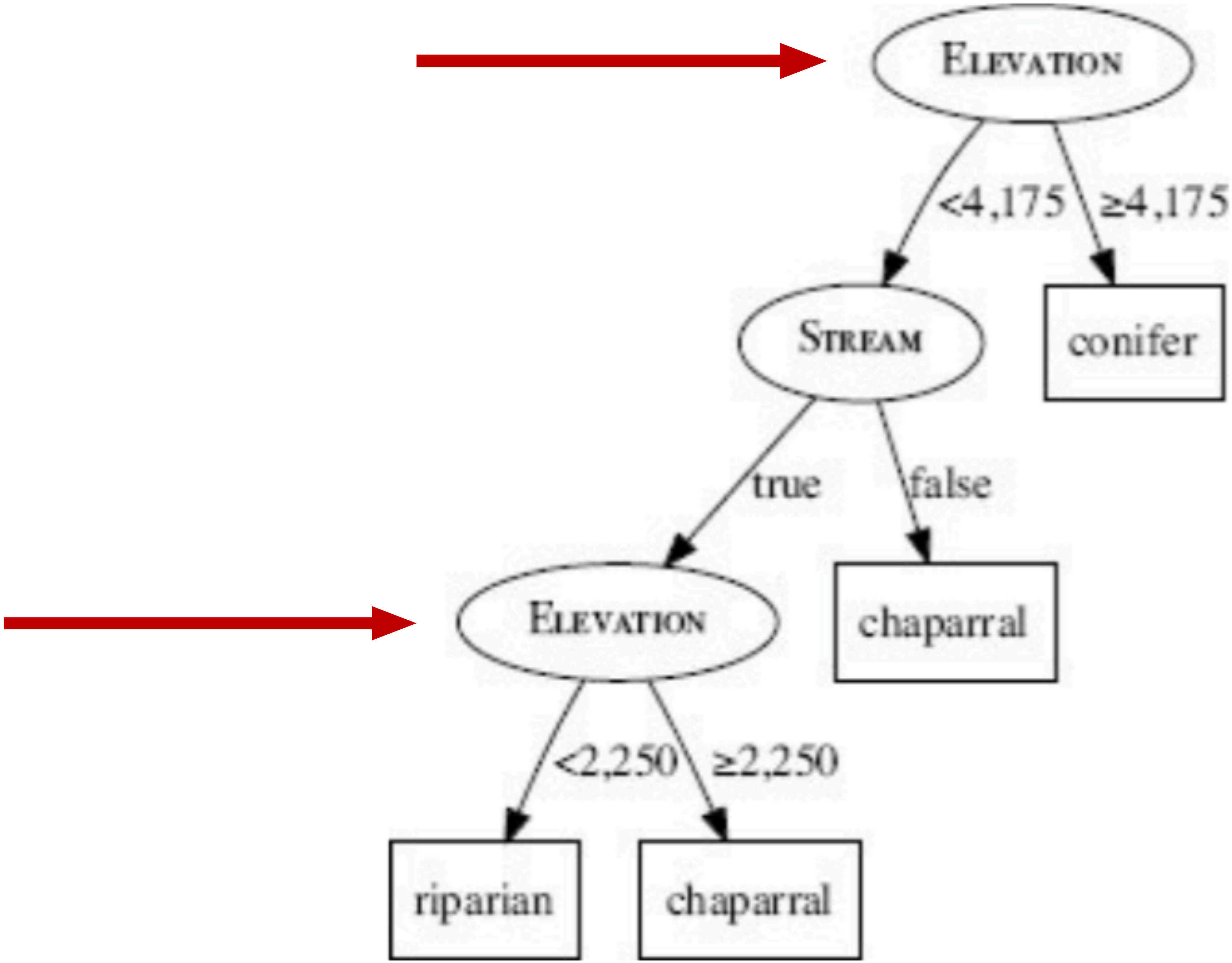
- the boundary between $\mathbf{d}_2$ and $\mathbf{d}_4$ is $\frac{300 + 1{,}200}{2} = 750$
- the boundary between $\mathbf{d}_4$ and $\mathbf{d}_3$ is $\frac{1{,}200 + 1{,}500}{2} = 1{,}350$
- the boundary between $\mathbf{d}_3$ and $\mathbf{d}_7$ is $\frac{1{,}500 + 3{,}000}{2} = 2{,}250$
- the boundary between $\mathbf{d}_1$ and $\mathbf{d}_5$ is $\frac{3{,}900 + 4{,}450}{2} = 4{,}175$

Split by Threshold	Part.	Instances	Partition Entropy	Rem.	Info. Gain
≥750	$\mathcal{D}_1$	$\mathbf{d}_2$	0.0	1.2507	0.3060
	$\mathcal{D}_2$	$\mathbf{d}_4, \mathbf{d}_3, \mathbf{d}_7, \mathbf{d}_1, \mathbf{d}_5, \mathbf{d}_6$	1.4591		
≥1,350	$\mathcal{D}_3$	$\mathbf{d}_2, \mathbf{d}_4$	1.0	1.3728	0.1839
	$\mathcal{D}_4$	$\mathbf{d}_3, \mathbf{d}_7, \mathbf{d}_1, \mathbf{d}_5, \mathbf{d}_6$	1.5219		
≥2,250	$\mathcal{D}_5$	$\mathbf{d}_2, \mathbf{d}_4, \mathbf{d}_3$	0.9183	0.9650	0.5917
	$\mathcal{D}_6$	$\mathbf{d}_7, \mathbf{d}_1, \mathbf{d}_5, \mathbf{d}_6$	1.0		
≥4,175	$\mathcal{D}_7$	$\mathbf{d}_2, \mathbf{d}_4, \mathbf{d}_3, \mathbf{d}_7, \mathbf{d}_1$	0.9710	0.6935	0.8631
	$\mathcal{D}_8$	$\mathbf{d}_5, \mathbf{d}_6$	0.0		

Unlike categorical features,

continuous features can be used at multiple points

, although the threshold will be different.


ELEVATION
<4,175
≥4,175
STREAM
conifer
true
false
ELEVATION
chaparral
<2,250
≥2,250
riparian
chaparral

Report: (10%)

The report should include the results, environment, using library and language, explain of your code and how to use it.

Accuracy, Precision and Recall: (20%)

We will test your source code and score base on your rank of following metrics:

$$1.5\times Accuracy + \sum_{i=0}^{2}(\,Precision_i + \,Recall_i\,)$$

Environment:

Your program will be executed on the following environment:

- Ubuntu 16.04.3 LTS
- gcc 5.4.0
- openjdk 1.8.0_131
- python 2.7.12
- python 3.5.2

Bonus: (20%)

Implement Random Forest algorithm and make a 'RF.sh' shell script to output the result with the same format.