Lab 5: Introducing Classification

Objectives:

- To gain hands-on experience classifying small dataset
- To implement concepts related to Decision Tree classifier (i.e. Entropy, Information Gain), along with using existing libraries.

```
# Run this cell if you use Colab
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

Code it yourself

```
import pandas as pd
import numpy as np

# Read the data
df = pd.read_csv('./toy_data.csv')
df
```

	age	income	student	credit rating	buys computer
0	<=30	high	no	fair	no
1	<=30	high	no	excellent	no
2	31-40	high	no	fair	yes
3	>40	medium	no	fair	yes
4	>40	low	yes	fair	yes
5	>40	low	yes	excellent	no
6	31-40	low	yes	excellent	yes
7	<=30	medium	no	fair	no
8	<=30	low	yes	fair	yes
9	>40	medium	yes	fair	yes
10	<=30	medium	yes	excellent	yes
11	31-40	medium	no	excellent	yes
12	31-40	high	yes	fair	yes
13	>40	medium	no	excellent	no

Next steps: Generate code with df | View recommended plots | New interactive sheet

```
print(df.info())
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 14 entries, 0 to 13
Data columns (total 5 columns):
 #   Column         Non-Null Count  Dtype
---  ------         --------------  -----
 0   age            14 non-null     object
 1   income         14 non-null     object
 2   student        14 non-null     object
 3   credit rating  14 non-null     object
 4   buys computer  14 non-null     object
dtypes: object(5)
memory usage: 692.0+ bytes
None
```

TODO: Write functions to compute Gain and Entropy, as discussed in the lecture.

```
import math


# Write your code here
entropy_t = pd.Series(df['buys computer'].value_counts().values/df['buys computer'].count())
entropy_t = -entropy_t.apply(lambda x: x*math.log2(x)).sum()
entropy_t
```

```
0.9402859586706311
```

```
ni_n = df.groupby('age')['buys computer'].count()/df['buys computer'].count()
entropy_age = (
    df.groupby('age')['buys computer'].value_counts()/df.groupby('age')['buys computer'].count()
    ).apply(lambda x: -x*math.log2(x)).groupby('age').sum()*ni_n

entropy_age
```

age	0
31-40	0.000000
<=30	0.346768
>40	0.346768

dtype: float64

```
gain_age = entropy_t - entropy_age.sum()
gain_age
```

```
0.24674981977443933
```

```
to_cal_attr = df.columns[:4]
gain_attr = {}
for attr in to_cal_attr:
    ni_n = df.groupby(attr)['buys computer'].count()/df['buys computer'].count()
    entropy_attr = (
        df.groupby(attr)['buys computer'].value_counts()/df.groupby(attr)['buys computer'].count()
        ).apply(lambda x: -x*math.log2(x)).groupby(attr).sum()*ni_n
    gain_attr[attr] = entropy_t - entropy_attr.sum()

gain_attr
```

```
{'age': 0.24674981977443933,
 'income': 0.02922256565895487,
 'student': 0.15183550136234159,
 'credit rating': 0.04812703040826949}
```

Using Libraries

Now that you know how to compute these values by yourselfs, now let's use some libraries.

Steps:

- Split the Data → Divide dataset into training (80%) and testing (20%).
- Train the Model → Fit a Decision Tree using the training data.
- Test the Model → Use the trained model to predict on test data.
- Evaluate Performance → Compare predictions with actual values (e.g., Accuracy Score).

Prepare features and labels.

```
# Features
features = df.drop('buys computer', axis=1)
features

# Alternatively, you can use this:
```

```
# features = df.iloc[:, :-1]
```

	age	income	student	credit rating
0	<=30	high	no	fair
1	<=30	high	no	excellent
2	31-40	high	no	fair
3	>40	medium	no	fair
4	>40	low	yes	fair
5	>40	low	yes	excellent
6	31-40	low	yes	excellent
7	<=30	medium	no	fair
8	<=30	low	yes	fair
9	>40	medium	yes	fair
10	<=30	medium	yes	excellent
11	31-40	medium	no	excellent
12	31-40	high	yes	fair
13	>40	medium	no	excellent

Next steps: Generate code with features | View recommended plots | New interactive sheet

```
# Labels (or Target)
labels = df['buys computer']
labels

# # Alternatively, you can use this:
# labels = df.iloc[:, [-1]]
```

	buys computer
0	no
1	no
2	yes
3	yes
4	yes
5	no
6	yes
7	no
8	yes
9	yes
10	yes
11	yes
12	yes
13	no

dtype: object

```
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier, plot_tree

# 1. Load the dataset
X = features.values  # Features
y = labels.values  # Target labels
```

```
# 2. Split the dataset into training (80%) and testing (20%)
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# 3. Create and train a Decision Tree model with entropy criterion
clf = DecisionTreeClassifier(criterion='entropy', max_depth=3, random_state=42)
clf.fit(X_train, y_train)
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
<ipython-input-25-047a60d5fd52> in <cell line: 0>()
     13 # 3. Create and train a Decision Tree model with entropy criterion
     14 clf = DecisionTreeClassifier(criterion='entropy', max_depth=3, random_state=42)
---> 15 clf.fit(X_train, y_train)

                                 5 frames
/usr/local/lib/python3.11/dist-packages/sklearn/utils/_array_api.py in _asarray_with_order(array, dtype, order, copy, xp, device)
    837             array = numpy.array(array, order=order, dtype=dtype)
    838         else:
--> 839             array = numpy.asarray(array, order=order, dtype=dtype)
    840
    841         # At this point array is a NumPy ndarray. We convert it to an array

ValueError: could not convert string to float: '31-40'
```

Next steps: Explain error

There's an error:

ValueError: could not convert string to float: '31-40'

```
from sklearn.preprocessing import LabelEncoder

# Initialize LabelEncoder
label_encoder = LabelEncoder()

# Apply Label Encoding for all categorical columns
df['age'] = label_encoder.fit_transform(df['age'])
df['income'] = label_encoder.fit_transform(df['income'])
df['student'] = label_encoder.fit_transform(df['student'])
df['credit rating'] = label_encoder.fit_transform(df['credit rating'])
df['buys computer'] = label_encoder.fit_transform(df['buys computer'])

# Display the encoded DataFrame
print(df)
```

```
    age  income  student  credit rating  buys computer
0     1       0        0              1              0
1     1       0        0              0              0
2     0       0        0              1              1
3     2       2        0              1              1
4     2       1        1              1              1
5     2       1        1              0              0
6     0       1        1              0              1
7     1       2        0              1              0
8     1       1        1              1              1
9     2       2        1              1              1
10    1       2        1              0              1
11    0       2        0              0              1
12    0       0        1              1              1
13    2       2        0              0              0
```

Let's check out an updated dataframe.

```
df
```

	age	income	student	credit rating	buys computer
0	1	0	0	1	0
1	1	0	0	0	0
2	0	0	0	1	1
3	2	2	0	1	1
4	2	1	1	1	1
5	2	1	1	0	0
6	0	1	1	0	1
7	1	2	0	1	0
8	1	1	1	1	1
9	2	2	1	1	1
10	1	2	1	0	1
11	0	2	0	0	1
12	0	0	1	1	1
13	2	2	0	0	0

Next steps: Generate code with df | View recommended plots | New interactive sheet

```
X = df.drop('buys computer', axis=1)  # Features
y = df['buys computer']  # Target
```

Let's continue where we left off!

```
# 2. Split the dataset into training (80%) and testing (20%)
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# 3. Create and train a Decision Tree model with entropy criterion
clf = DecisionTreeClassifier(criterion='entropy', max_depth=3, random_state=42)
clf.fit(X_train, y_train)
```

```
DecisionTreeClassifier(criterion='entropy', max_depth=3, random_state=42)
```

```
print(X_train.shape)
print(X_test.shape)
```

```
(11, 4)
(3, 4)
```

Now we're going build the Decision Tree Classifier

```
from sklearn.tree import DecisionTreeClassifier

# Initialize the Decision Tree classifier
clf = DecisionTreeClassifier(criterion='entropy', random_state=42)  # Using 'entropy' as the criterion

# Train the model
clf.fit(X_train, y_train)

# Predict on the test set
y_pred = clf.predict(X_test)
```

And evaluate our model.

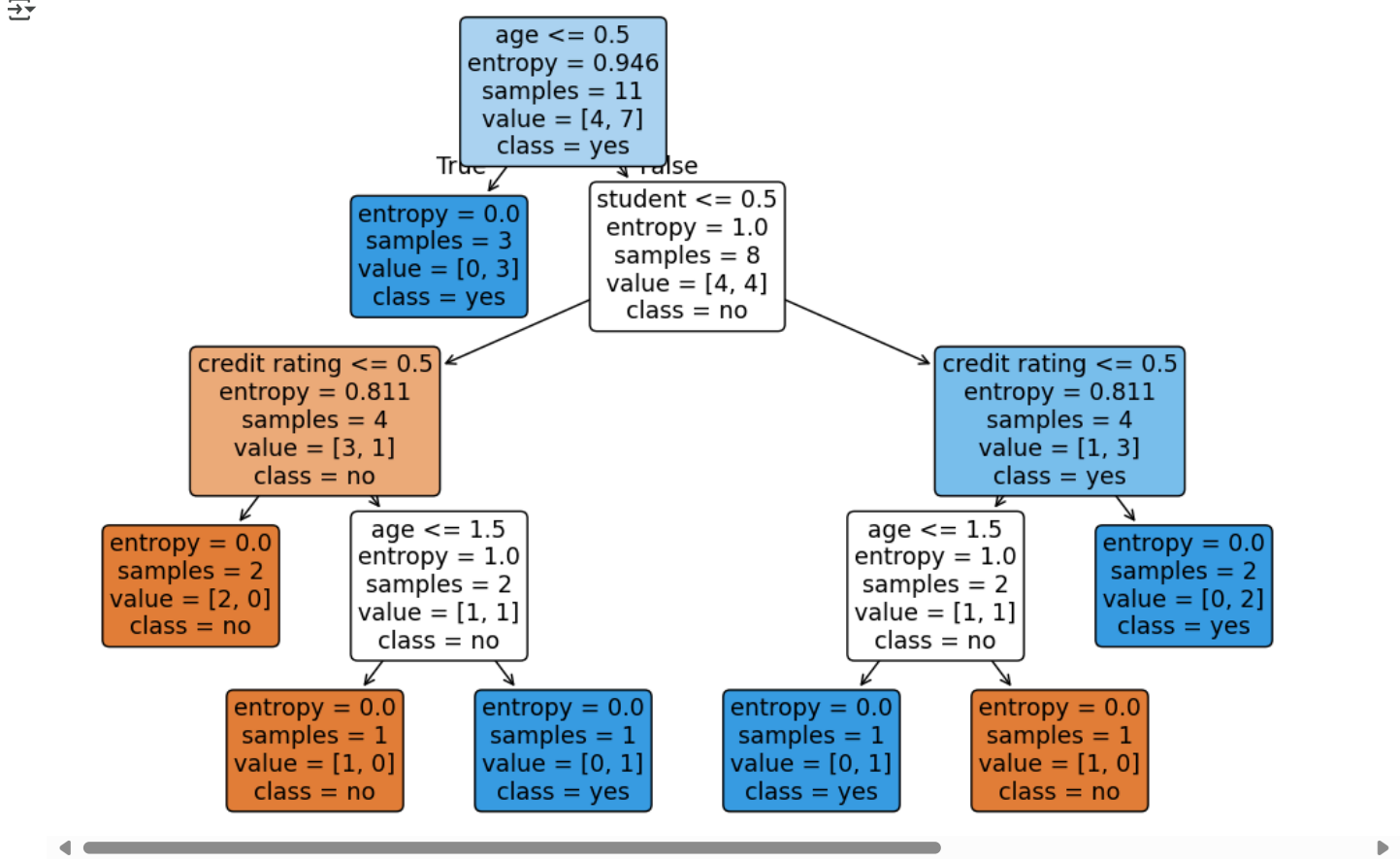
```
from sklearn.metrics import accuracy_score, classification_report, confusion_matrix
```

```
# Calculate accuracy
accuracy = accuracy_score(y_test, y_pred)
print(f"Accuracy: {accuracy:.2f}")

# Classification report
print("Classification Report:")
print(classification_report(y_test, y_pred))

# Confusion Matrix
print("Confusion Matrix:")
print(confusion_matrix(y_test, y_pred))
```

```
Accuracy: 1.00
Classification Report:
              precision    recall  f1-score   support

           0       1.00      1.00      1.00         1
           1       1.00      1.00      1.00         2

    accuracy                           1.00         3
   macro avg       1.00      1.00      1.00         3
weighted avg       1.00      1.00      1.00         3

Confusion Matrix:
[[1 0]
 [0 2]]
```

And visualize our tree!

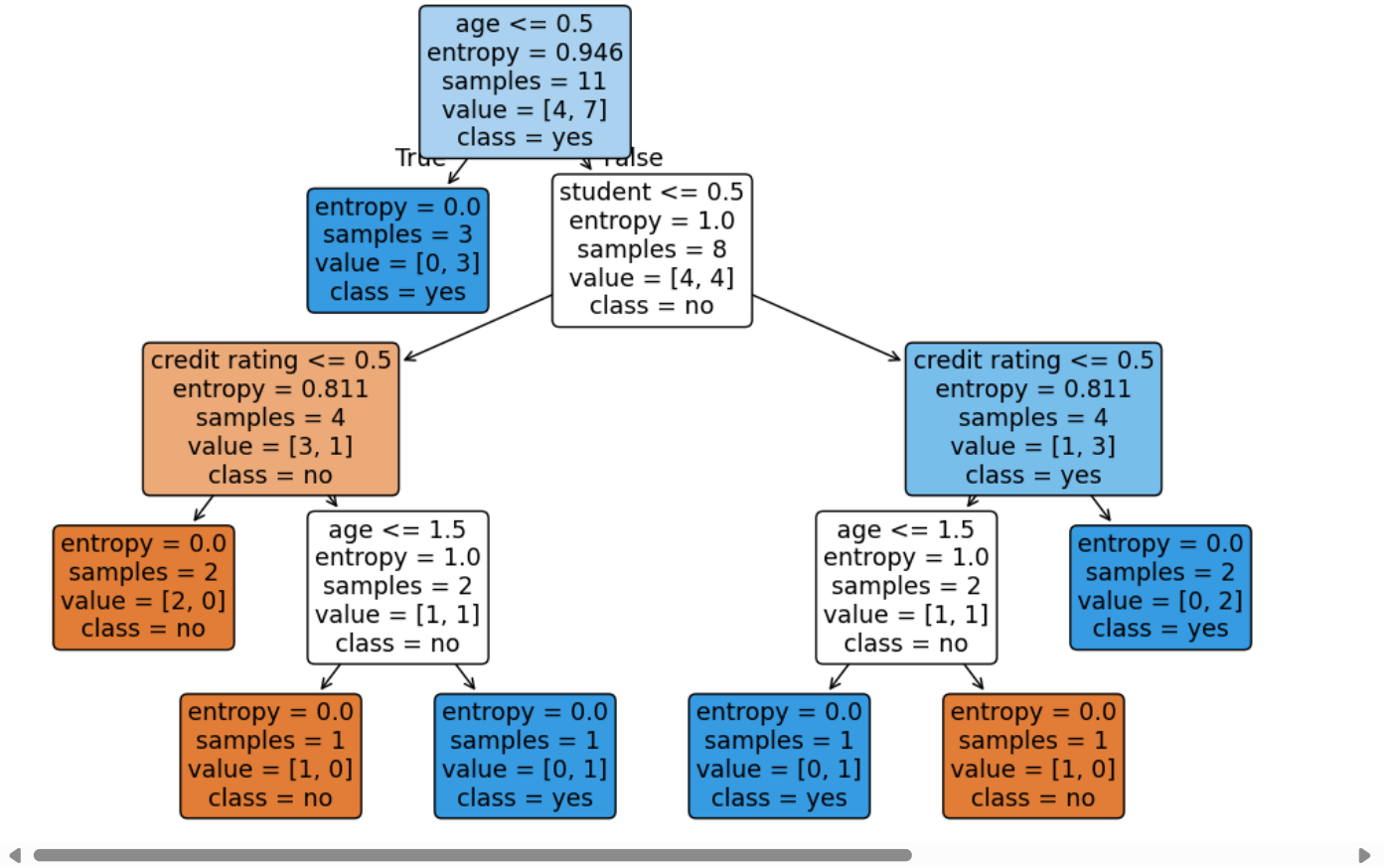
```
import matplotlib.pyplot as plt
from sklearn.tree import plot_tree

# Plot the decision tree
plt.figure(figsize=(12, 8))
plot_tree(clf, filled=True, feature_names=X.columns, class_names=['no', 'yes'], rounded=True)
plt.show()
```



Put them all together.

```
import pandas as pd
from sklearn.preprocessing import LabelEncoder
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import accuracy_score, classification_report, confusion_matrix
import matplotlib.pyplot as plt
from sklearn.tree import plot_tree

# data
data = pd.read_csv('./toy_data.csv')

df = pd.DataFrame(data)

# Encode categorical columns using LabelEncoder
label_encoder = LabelEncoder()
df['age'] = label_encoder.fit_transform(df['age'])
df['income'] = label_encoder.fit_transform(df['income'])
df['student'] = label_encoder.fit_transform(df['student'])
df['credit rating'] = label_encoder.fit_transform(df['credit rating'])
df['buys computer'] = label_encoder.fit_transform(df['buys computer'])

# Separate features (X) and target (y)
X = df.drop('buys computer', axis=1)
y = df['buys computer']

# Split the dataset into training and test sets (80% train, 20% test)
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Initialize the Decision Tree classifier
clf = DecisionTreeClassifier(criterion='entropy', random_state=42)

# Train the model
clf.fit(X_train, y_train)

# Predict on the test set
y_pred = clf.predict(X_test)

# Calculate accuracy
accuracy = accuracy_score(y_test, y_pred)
print(f"Accuracy: {accuracy:.2f}")

# Classification report
print("Classification Report:")
print(classification_report(y_test, y_pred))

# Confusion Matrix
print("Confusion Matrix:")
print(confusion_matrix(y_test, y_pred))

# Plot the decision tree
plt.figure(figsize=(12, 8))
plot_tree(clf, filled=True, feature_names=X.columns, class_names=['no', 'yes'], rounded=True)
plt.show()
```

```
Accuracy: 1.00
Classification Report:
              precision    recall  f1-score   support

           0       1.00      1.00      1.00         1
           1       1.00      1.00      1.00         2

    accuracy                           1.00         3
   macro avg       1.00      1.00      1.00         3
weighted avg       1.00      1.00      1.00         3

Confusion Matrix:
[[1 0]
 [0 2]]
```



Is the output tree the same as what you calculated yourself? Explain in your own words why they are the same or different.

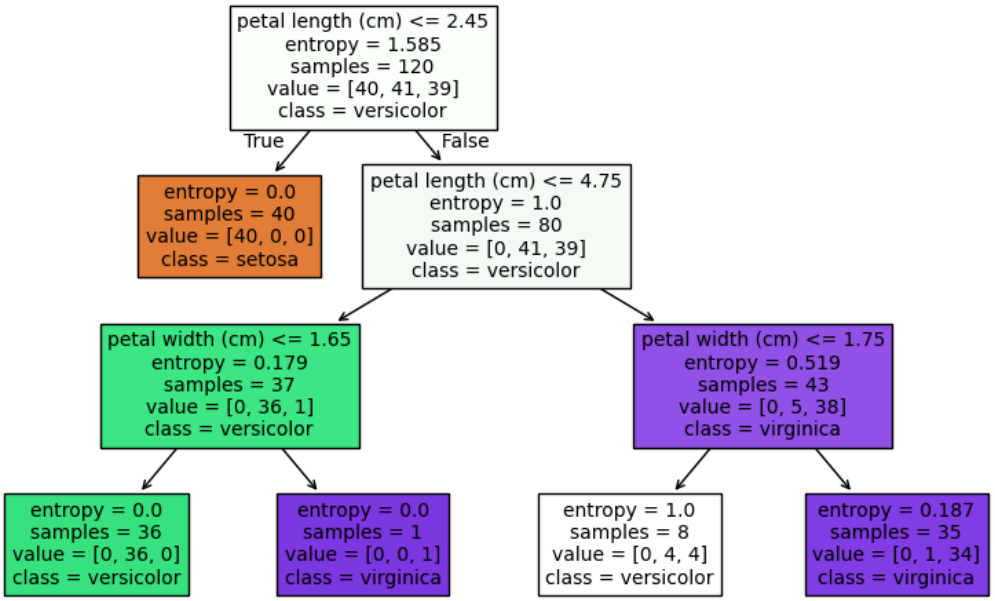
Ans: Nope, The output tree is different because the model was trained on only 80% of the data, but the manual calculation used all the data. This caused changes in entropy values, information gain, and the tree structure.

Another example, another dataset -- Iris

```
from sklearn.datasets import load_iris

# 1. Load the Iris dataset
iris = load_iris()
X = iris.data  # Features
y = iris.target  # Target labels

# 2. Split the dataset into training (80%) and testing (20%)
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# 3. Create and train a Decision Tree model with entropy criterion
clf = DecisionTreeClassifier(criterion='entropy', max_depth=3, random_state=42)
clf.fit(X_train, y_train)

# 4. Make predictions on the test set
```

```
y_pred = clf.predict(X_test)

# 5. Evaluate the model
accuracy = accuracy_score(y_test, y_pred)
print(f"Model Accuracy: {accuracy:.2f}")

# 6. Visualize the Decision Tree
plt.figure(figsize=(10, 6))
plot_tree(clf, filled=True, feature_names=iris.feature_names, class_names=iris.target_names)
plt.show()
```

```
Model Accuracy: 1.00
```



Start coding or generate with AI.

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