01 - Supervised Learning - Classification - Decision Trees(Solution)_st122097_Thantham

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1 Programming for Data Science and Artificial Intelligence

1.1 Supervised Learning - Classification - Decision Trees

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1.3.1 ===Task===

Let's modify the above scratch code to - Modify the scratch code so it can accept an hyperparameter max_depth, in which it will continue create the tree until max_depth is reached. - Put everything into a class DecisionTree. It should have at least two methods, fit(), and predict() - Load the iris data and try with your class

[1]:
```
import numpy as np
import matplotlib.pyplot as plt
```

1.4 Decision Tree Class

[2]:
```
class DecisionTree:


    def __init__(self, max_depth = None):

        # If user not put max_depth or put negative depth -> set to infinite
        if (max_depth is None) or (max_depth <1):
            print('{Warning]: max_depth defined is None or less than 1, model␣
↪will set to no limit')
            self.max_depth = np.inf
        else:
            self.max_depth = max_depth

    def fit(self, X, y):
        self.n_classes_ = len(set(y)) # get unique class
        self.n_features_ = X.shape[1] # get number of features
        self.tree_ = self._grow_tree(X, y) # make a tree
```

```
    def predict(self, X):
        # For each x_test_i -> predict class
        return np.array([self._predict(x_i) for x_i in X])

    # Reuseable function to create new Node
    def _grow_tree(self, X, y, depth=0):

        # get number sample for each output class
        num_samples_per_class = [np.sum(y == i) for i in range(self.n_classes_)]

        # get the output class that has largest number of samples
        predicted_class = np.argmax(num_samples_per_class)

        # create a Node with that class
        node = self.Node(predicted_class=predicted_class)

        # Check if depth of tree is exceed max_depth
        if depth < self.max_depth:

            # Find feature_idx and feature_threshold value from finding best␣
↪split
            idx, thr = self._best_split(X, y)

            # check if idx exists
            if idx is not None:

                # Is it on Left?
                indices_left = X[:, idx] < thr

                # Point to the left
                X_left, y_left = X[indices_left], y[indices_left]

                # Point to the right (from not left)
                X_right, y_right = X[~indices_left], y[~indices_left]

                #  set identity feature at node
                node.feature_index = idx

                # set threshold for node
                node.threshold = thr

                # continuely grow left and right node
                node.left = self._grow_tree(X_left, y_left, depth + 1)
                node.right = self._grow_tree(X_right, y_right, depth + 1)

        return node
```

```
def _predict(self, inputs):

    #init tree for prediction
    node = self.tree_

    # If next branch exists -> go next branch
    while node.left:

        # test on if feature that current node less than threshold
        if inputs[node.feature_index] < node.threshold:

            # go to the left leaf
            node = node.left
        else:
            # go to the right leaf
            node = node.right

    return node.predicted_class

def _best_split(self, X, y):

    # get number of samples
    m = y.size

    # if no samples more, than exit
    if m <= 1:
        return None, None

    # count samples that are each class
    num_parent = [np.sum(y == c) for c in range(self.n_classes_)]

    # find gini Index using I_g equation
    best_gini = 1.0 - sum((n / m) ** 2 for n in num_parent)

    # init best split indx and threshold value
    best_idx, best_thr = None, None

    # looping all features to find best split
    for idx in range(self.n_features_):

        # make list of threshold split
        thresholds, classes = zip(*sorted(zip(X[:, idx], y)))

        # make countable list
        num_left = [0] * self.n_classes_
```

```
            # make init right
            num_right = num_parent.copy()

            # try to calcualate left to right
            for i in range(1, m):

                #
                c = classes[i - 1]
                num_left[c] += 1
                num_right[c] -= 1

                # gini index on left
                gini_left = 1.0 - sum(
                    (num_left[x] / i) ** 2 for x in range(self.n_classes_)
                )
                # gini index on right
                gini_right = 1.0 - sum(
                    (num_right[x] / (m - i)) ** 2 for x in range(self.
↪n_classes_)
                )

                # gini on node
                gini = (i * gini_left + (m - i) * gini_right) / m

                #  If out of threshold exists
                if thresholds[i] == thresholds[i - 1]:
                    continue

                # if current gini is better previous
                if gini < best_gini:
                    best_gini = gini # set it as best gini
                    best_idx = idx # set idx for best gini
                    best_thr = (thresholds[i] + thresholds[i - 1]) / 2 # calc␣
↪threshold which is between best split

        return best_idx, best_thr

    # Inner class for Node Generation
    class Node:

        def __init__(self, predicted_class):

            # Being predicted to be class
            self.predicted_class = predicted_class

            # Will test on feature at
            self.feature_index = 0
```

```
            # With Threshold
            self.threshold = 0

            # Connect with Left and Right Node at
            self.left = None
            self.right = None
```

1.4.1 How to use DecisionTree model

DecisionTree(max_depth = None)

Hyperparameter

- max_depth: int or None (if None or negative, depth will be st to infinite automatically.)

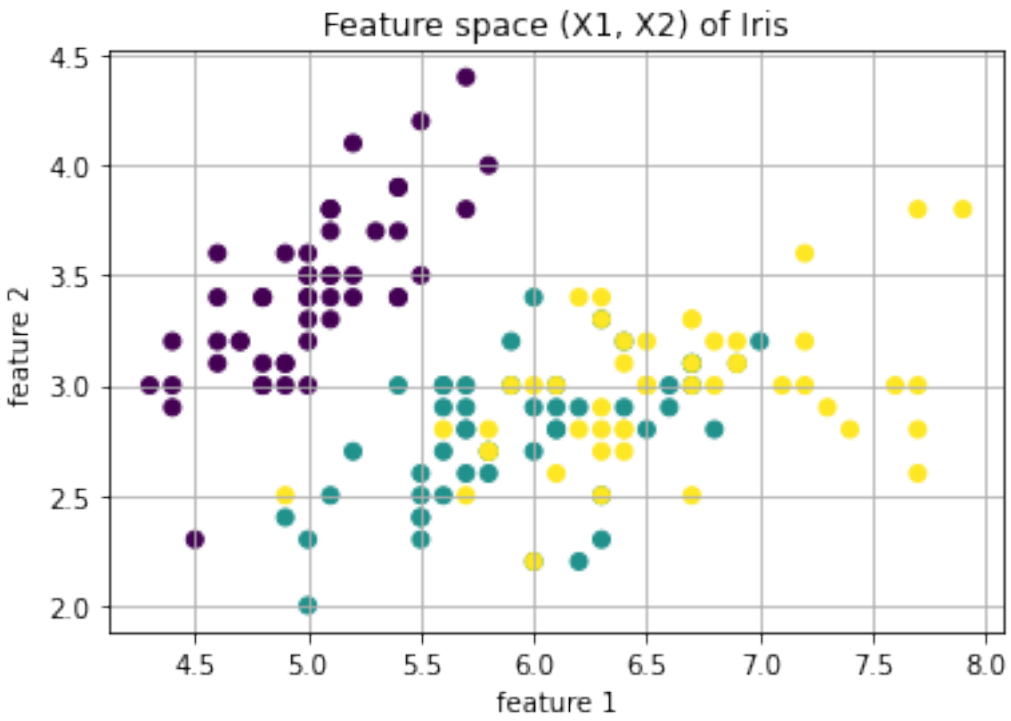
1.5 Perform Decision Tree Classisification on Iris Data

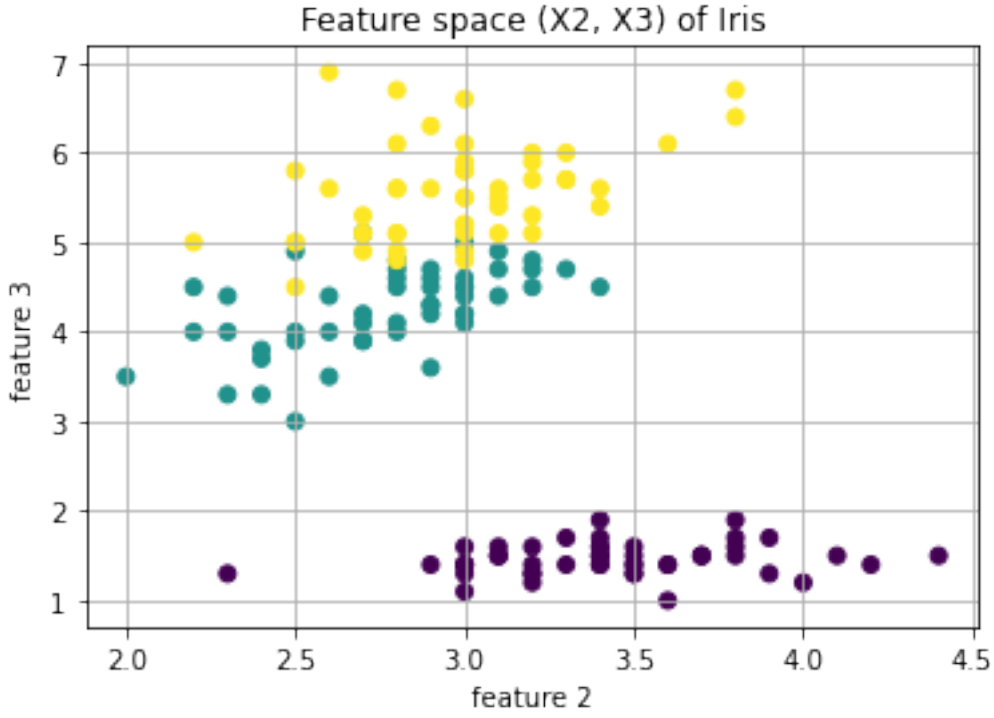
Load dataset

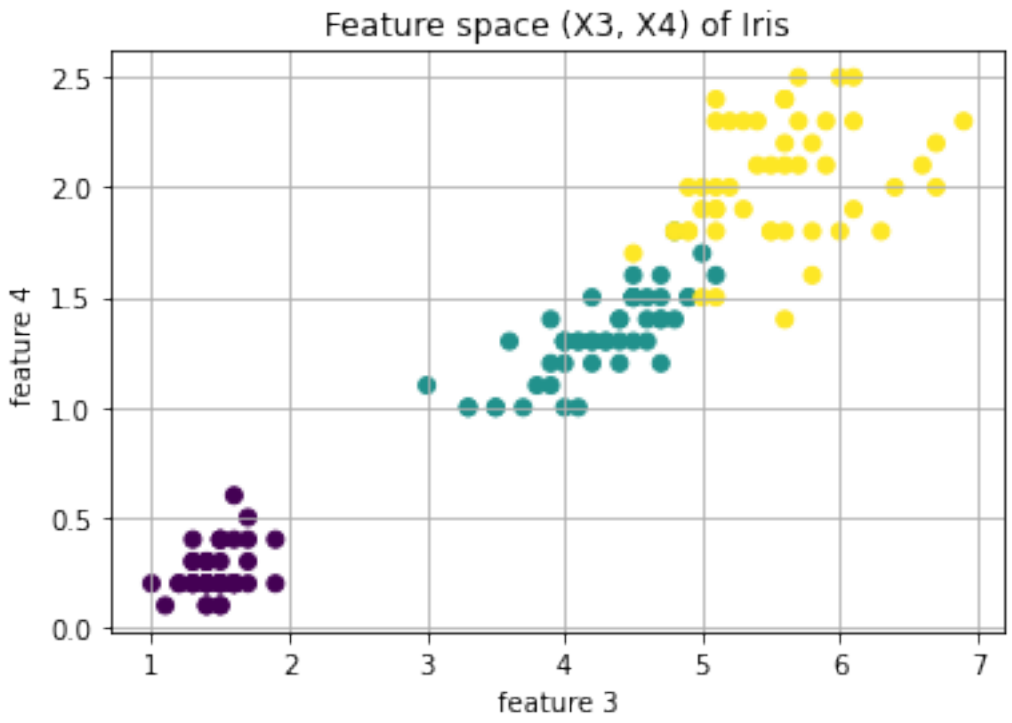
[3]:
```
from sklearn.datasets import load_iris

dataset = load_iris()
X, y = dataset.data, dataset.target
```

Try to see what are the scatter will looks like

[4]:
```
plt.scatter(X[:, 0], X[:, 1], c=y)
plt.xlabel('feature 1')
plt.ylabel('feature 2')
plt.title('Feature space (X1, X2) of Iris')
plt.grid()
plt.show()
plt.scatter(X[:, 1], X[:, 2], c=y)
plt.xlabel('feature 2')
plt.ylabel('feature 3')
plt.title('Feature space (X2, X3) of Iris')
plt.grid()
plt.show()
plt.scatter(X[:, 2], X[:, 3], c=y)
plt.xlabel('feature 3')
plt.ylabel('feature 4')
plt.title('Feature space (X3, X4) of Iris')
plt.grid()
plt.show()
```


Feature space (X1, X2) of Iris
feature 2
feature 1
4.5
4.0
3.5
3.0
2.5
2.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0


Feature space (X2, X3) of Iris
feature 3
feature 2
7
6
5
4
3
2
1
2.0
2.5
3.0
3.5
4.0
4.5



However, Decision tree will perform on between values threshold. So, we might not need to normalize the data.

Split Data to Train and Test

[5]:
```
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3,␣
↪random_state=48)
```

Instantiate and Fit The Model Lets try model

[6]:
```
model = DecisionTree(max_depth=5)
model.fit(X_train, y_train)
```

Predict yhat After fitting model, we futher predict values

[7]:
```
y_pred = model.predict(X_test)
```

The predicted values will looks like this

[8]:
```
y_pred[:10]
```

[8]:
```
array([1, 1, 2, 0, 2, 2, 0, 2, 0, 1])
```

Model Evaluation

[9]:
```
from sklearn.metrics import classification_report

print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        11
           1       0.94      0.89      0.91        18
           2       0.88      0.94      0.91        16

    accuracy                           0.93        45
   macro avg       0.94      0.94      0.94        45
weighted avg       0.93      0.93      0.93        45
```

1.5.1 Try on different implementation with infinite depth

[10]:
```
model_inf = DecisionTree(max_depth=None)
model_inf.fit(X_train, y_train)
y_pred_inf = model_inf.predict(X_test)
print(classification_report(y_test, y_pred_inf))
```

```
{Warning]: max_depth defined is None or less than 1, model will set to no limit
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        11
           1       0.94      0.89      0.91        18
           2       0.88      0.94      0.91        16

    accuracy                           0.93        45
   macro avg       0.94      0.94      0.94        45
weighted avg       0.93      0.93      0.93        45
```

[ ]:
```

```