Experiment Schema

March 20, 2020

[1]:
```python
# import needed library
from sklearn.datasets import load_iris
import pandas as pd
from sklearn.preprocessing import LabelEncoder
import math
import numpy as np
import random

# train test split
from sklearn.model_selection import train_test_split

# Kfold
from sklearn.model_selection import KFold

# regex
import re
```

[2]:
```python
#load iris dataset
data_iris = load_iris()
iris_X, iris_y = load_iris(return_X_y=True)
feature_iris = data_iris['feature_names']
```

[3]:
```python
#transform iris into dataframe
iris_X=pd.DataFrame(iris_X)
iris_y=pd.DataFrame(iris_y)
```

[4]:
```python
#create index so be merge
iris_X=iris_X.reset_index()
iris_y=iris_y.reset_index()
```

[5]:
```python
iris_X.rename(columns = {0:feature_iris[0],1:feature_iris[1],2:
↪feature_iris[2],3:feature_iris[3]}, inplace = True)
```

[6]:
```python
iris_y.rename(columns = {0:'target'}, inplace = True)
```

[7]:
```
#merge dataset iris
iris=iris_X.merge(iris_y)
```

[8]:
```
#drop index
iris.drop("index",axis=1,inplace=True)
```

[9]:
```
def entropy(parsed_data, target_attribute):
    parsed_value_target = {}
    total_value_target = 0

    for i in parsed_data[target_attribute]:
        if i is not None:
            if i not in parsed_value_target:
                parsed_value_target[i] = 1
            else:
                parsed_value_target[i] += 1

            total_value_target += 1

    log_result = 0

    for i in parsed_value_target:
        log_result += float(parsed_value_target[i])/total_value_target * math.
↪log((float(parsed_value_target[i])/total_value_target), 2)

    return -1 * log_result
```

[10]:
```
# hasn't handle after universal entropy
def information_gain(data, gain_attribute, target_attribute):
    gain_result = 0
    attribute_entropy_result = 0
    parsed_attribute_count = {}
    total_attribute_count = 0

    for i in data[gain_attribute]:
        if i is not None:
            if i not in parsed_attribute_count:
                parsed_attribute_count[i] = 1
            else:
                parsed_attribute_count[i] += 1

            total_attribute_count += 1

    for i in parsed_attribute_count:
        parsed_data = data.loc[data[gain_attribute]==i]
        attribute_entropy_result += float(parsed_attribute_count[i])/
↪total_attribute_count * entropy(parsed_data, target_attribute)
```

```python
    gain_result += entropy(data,target_attribute) + (-1 *␣
↪attribute_entropy_result)
    return gain_result
```

[11]:
```python
def split_information(data, gain_attribute):
    res = entropy(data, gain_attribute)
    if(res==0):
        res=0.00000001
    return res
```

[12]:
```python
def gain_ratio(data, gain_attribute, target_attribute):
    res = information_gain(data, gain_attribute, target_attribute) /␣
↪split_information(data, gain_attribute)
    return res
```

[13]:
```python
def gain_ratio_continous(data, gain_attribute, target_attribute):
    res = information_gain_continous(data, gain_attribute, target_attribute)[0]␣
↪/ split_information(data, gain_attribute)
    return res,information_gain_continous(data, gain_attribute,␣
↪target_attribute)[1]
```

[14]:
```python
def best_attribute(data,target_attribute,is_IG):
    gain_attribute = {
        'value': 0,
        'name': ''
    }


    for i in data.columns:
        if (i != target_attribute):
            if is_IG:
                if information_gain(data, i, target_attribute) >␣
↪gain_attribute['value']:
                    gain_attribute['value'] = information_gain(data, i,␣
↪target_attribute)
                    gain_attribute['name'] = i
            else:
                if gain_ratio(data, i, target_attribute) >␣
↪gain_attribute['value']:
                    gain_attribute['value'] = gain_ratio(data, i,␣
↪target_attribute)
                    gain_attribute['name'] = i


    return gain_attribute['name']
```

[15]:
```python
import math

class Node:
    def __init__(self, attribute=None, label=None, vertex=None):
        self.attribute = attribute
        self.label = label
        self.vertex = vertex
        self.children = {}
        self.most_common_label = None

    def set_most_common_label(self, most_common_label):
        self.most_common_label = most_common_label

    def get_most_common_label(self):
        return self.most_common_label

    def setAttribute(self, attribute):
        self.attribute = attribute

    def setLabel(self, label):
        self.label = label

    def setVertex(self, vertex):
        self.vertex = vertex

    def addChildren(self, attributeValue, node):
        self.children[attributeValue] = node

    def getChildren(self):
        return self.children

    def getLabel(self):
        return self.label

    def getVertex(self):
        return self.vertex
```

[16]:
```python
def get_most_common_label(data, target_attribute):
    parsed_value_target = {}

    for i in data[target_attribute]:
        if i is not None:
            if i not in parsed_value_target:
                parsed_value_target[i] = 1
            else:
                parsed_value_target[i] += 1
```

```
    most_common = {
        'value': 0,
        'name': ''
    }

    for i in parsed_value_target:
        if parsed_value_target[i] > most_common['value']:
            most_common['value'] = parsed_value_target[i]
            most_common['name'] = i

    return most_common['name']
```

[17]:
```
def most_common_label_target(data,target_attribute):
    most_comm = None
    occ = 0;
    for i in data[target_attribute].unique():
        if data[data[target_attribute] == i].shape[0] >  occ:
            most_comm = i
            occ = data[data[target_attribute] == i].shape[0]
    return most_comm
```

[18]:
```
def id3(data, target_attribute, is_IG):
    node = Node()
    if data[target_attribute].nunique()==1:
        node.setLabel(data[target_attribute].unique()[0])
        return node

    elif len(data.columns)==1:
        node.setLabel(get_most_common_label(data, target_attribute))
        return node

    else:
        best_attribute_ = best_attribute(data,target_attribute,is_IG)
        node.setAttribute(best_attribute_)
        for i in data[best_attribute_].unique():
            node.addChildren(i,id3(data.
 ↪loc[data[best_attribute_]==i],target_attribute,is_IG))
            node.
 ↪set_most_common_label(most_common_label_target(data,target_attribute))

    return node
```

[19]:
```
def print_tree(node,depth):
    if node.label is not None:
        print("    "*(depth+1) +str(node.label))
    else:
        print("    "*depth + "["+ node.attribute +"]")
```

```
        for i in node.children:
            print("----"*(depth+1) +str(i))
            print_tree(node.children[i],depth+1)
```

[20]:
```
def copy_tree(node):
    temp_node = Node()
    if node.label is not None:
        temp_node.setLabel(node.label)
    else:
        temp_node.setAttribute(node.attribute)
        for i in node.children:
            temp= Node()
            temp= node.children[i]
            temp_node.addChildren(i, temp)
    return temp_node
```

[21]:
```
def check_tree(node,data,index,result, target_attribute):
    if node.label is not None:
        result.append(node.getLabel())
    else:
        if data.loc[index, node.attribute] is None:
            result.append(node.get_most_common_label())
        for i in node.children:
            if i==data.loc[index,node.attribute]:
                check_tree(node.children[i],data,index,result, target_attribute)
```

[22]:
```
def pred(data,model,target_attribute):
    result = []
    for i in range(len(data)):
        check_tree(model,data[i:i+1],i,result, target_attribute)
        data = {target_attribute:result}
    return pd.DataFrame(data)
```

[23]:
```
# hasn't handle after universal entropy
def information_gain_continous(data, gain_attribute, target_attribute):
    gain_result = 0
    save_boundary = -1
    min_entropy = 999999
    data = data.sort_values(gain_attribute)
    data=data.reset_index().drop('index',axis=1)
    length_data = len(data)
    for i in range(length_data):
        if (i!=length_data-1):
            if (data.loc[i,target_attribute] != data.loc[i+1,target_attribute]):
                temp_boundary = (data.loc[i,gain_attribute] + data.
 ↪loc[i+1,gain_attribute])/2
```

```
                parsed_data_upper = data.
↪loc[data[gain_attribute]>=temp_boundary]
                parsed_data_lower = data.loc[data[gain_attribute]<temp_boundary]
                len_parsed = len(parsed_data_upper)
                temp_entropy = float(len_parsed)/length_data *␣
↪entropy(parsed_data_upper, target_attribute) +␣
↪float((length_data-len_parsed))/length_data * entropy(parsed_data_lower,␣
↪target_attribute)
                if temp_entropy < min_entropy:
                    #print(gain_attribute, temp_boundary, temp_entropy)
                    min_entropy = temp_entropy
                    save_boundary = temp_boundary

    gain_result += entropy(data,target_attribute) + (-1 * min_entropy)
    return gain_result,save_boundary
```

[24]:
```
information_gain_continous(iris, 'petal length (cm)', 'target')
```

[24]: (0.9182958340544894, 2.45)

[25]:
```
def best_attribute_c45(data,target_attribute,is_IG):
    gain_attribute = {
        'value': 0,
        'name': '',
        'boundary': -99999999
    }


    for i in data.columns:
        if (i != target_attribute):
            if is_IG:
                if data[i].dtypes in [pd.np.dtype('float64'), pd.np.
↪dtype('float32')]:
                    ig = information_gain_continous(data, i, target_attribute)
                    if ig[0] > gain_attribute['value']:
                        gain_attribute['value'] = ig[0]
                        gain_attribute['name'] = i
                        gain_attribute['boundary'] = ig[1]
                else:
                    if information_gain(data, i, target_attribute) >␣
↪gain_attribute['value']:
                        gain_attribute['value'] = information_gain(data, i,␣
↪target_attribute)
                        gain_attribute['name'] = i
            else:
                if data[i].dtypes in [pd.np.dtype('float64'), pd.np.
↪dtype('float32')]:
```

```
                ig = gain_ratio_continous(data, i, target_attribute)
                if ig[0] > gain_attribute['value']:
                    gain_attribute['value'] = ig[0]
                    gain_attribute['name'] = i
                    gain_attribute['boundary'] = ig[1]
            else:
                if gain_ratio(data, i, target_attribute) >␣
↪gain_attribute['value']:
                    gain_attribute['value'] = gain_ratio(data, i,␣
↪target_attribute)
                    gain_attribute['name'] = i

    return gain_attribute['name'],round(gain_attribute['boundary'],2)
```

[26]:
```
best_attribute_c45(iris,'target',False)
```

[26]:
```
('petal width (cm)', 0.8)
```

[27]:
```
def c45(data, target_attribute,is_IG):
    node = Node()
    if data[target_attribute].nunique()==1:
        node.setLabel(data[target_attribute].unique()[0])
        return node

    elif len(data.columns)==1:
        node.setLabel(get_most_common_label(data, target_attribute))
        return node

    else:
        best_attribute_,bound  = best_attribute_c45(data,target_attribute,is_IG)
        #print(best_attribute_)
        node.setAttribute(best_attribute_)
        node.
↪set_most_common_label(most_common_label_target(data,target_attribute))
        if bound==-99999999:
            for i in data[best_attribute_].unique():
                node.addChildren(i,c45(data.
↪loc[data[best_attribute_]==i],target_attribute,is_IG))
        else:
            node.addChildren('>='+str(bound),c45(data.
↪loc[data[best_attribute_]>=bound],target_attribute,is_IG))
            node.addChildren('<'+str(bound),c45(data.
↪loc[data[best_attribute_]<bound],target_attribute,is_IG))
    return node
```

[28]:
```
def c45_prun(data, target_attribute,is_IG,vertex_=None):
    node = Node(vertex = vertex_)
    if data[target_attribute].nunique()==1:
        node.setLabel(data[target_attribute].unique()[0])
        return node

    elif len(data.columns)==1:
        node.setLabel(get_most_common_label(data, target_attribute))
        return node

    else:
        best_attribute_,bound  = best_attribute_c45(data,target_attribute,is_IG)
        #print(best_attribute_)
        node.setAttribute(best_attribute_)
        node.
 ↪set_most_common_label(most_common_label_target(data,target_attribute))
        if bound==-99999999:
            for i in data[best_attribute_].unique():
                node.addChildren(i,c45_prun(data.
 ↪loc[data[best_attribute_]==i],target_attribute,is_IG,i))
        else:
            node.addChildren('>='+str(bound),c45_prun(data.
 ↪loc[data[best_attribute_]>=bound],target_attribute,is_IG,'>='+str(bound)))
            node.addChildren('<'+str(bound),c45_prun(data.
 ↪loc[data[best_attribute_]<bound],target_attribute,is_IG,'<'+str(bound)))
    return node
```

[29]:
```
c45(iris, "target",True)
```

[29]:
```
<__main__.Node at 0x7f2d0bddc198>
```

[30]:
```
print_tree(c45(iris, "target",True),0)
```

```
[petal length (cm)]
---->=2.45
    [petal width (cm)]
-------->=1.75
        [sepal width (cm)]
------------>=3.15
            [sepal length (cm)]
---------------->=6.05
                    2
----------------<6.05
                    1
------------<3.15
                2
--------<1.75
```

```
        [petal length (cm)]
------------>=4.95
            [petal width (cm)]
---------------->=1.55
                [sepal length (cm)]
-------------------->=6.95
                        2
--------------------<6.95
                        1
----------------<1.55
                    2
------------<4.95
            [petal width (cm)]
---------------->=1.65
                    2
----------------<1.65
                    1
----<2.45
        0
```

[31]:
```python
def check_tree_c45(node,data,index,result, target_attribute):
    if node.label is not None:
        result.append(node.getLabel())
    else:
        if data.loc[index, node.attribute] is None:
            result.append(node.get_most_common_label())
        else:
            for i in node.children:
                #print(i)
                if i[0]=='<':
                    #print(i,2)
                    bound=float(i[1:])
                    if bound>data.loc[index,node.attribute]:
                        #print(data.loc[index,node.attribute])
                        check_tree_c45(node.children[i],data,index,result,␣
↪target_attribute)
                elif i[0]=='>':
                    bound=float(i[2:])
                    #print(i,1)
                    if bound<=data.loc[index,node.attribute]:
                        #print(data.loc[index,node.attribute])
                        check_tree_c45(node.children[i],data,index,result,␣
↪target_attribute)
                else:
                    if i==data.loc[index,node.attribute]:
                        check_tree(node.children[i],data,index,result,␣
↪target_attribute)
```

```
[32]: def pred_c45(data,model,target_attribute):
          result = []
          for i in range(len(data)):
              check_tree_c45(model,data[i:i+1],i,result, target_attribute)
          data = { target_attribute: data[target_attribute]
                  ,'prediction':result}
          return pd.DataFrame(data)
```

```
[33]: p=iris
```

```
[34]: p=p.drop('target',axis=1)
```

```
[35]: p=p.reset_index().drop('index',axis=1)
```

```
[36]: p['sepal width (cm)'] = None
```

```
[37]: def accuracy(pred,data):
          cnt = 0
          for i in range(len(pred)):
              if pred.loc[i] == data.loc[i]:
                  cnt+=1
          return cnt*100/len(pred)
```

```
[38]: def get_data_validate(data):
          data_column = data.columns
          data_10 = pd.DataFrame(columns=data_column)
          data_90 = pd.DataFrame(columns=data_column)
          #print(data_column)
          count_10 = 0
          count_90 = 0

          for i in range(data.shape[0]):
              if(i%10 == 1):
                  # Pass the row elements as key value pairs to append() function
                  data_10 = data_10.append(data.loc[[i]] , ignore_index=True)
              else:
                  data_90 = data_90.append(data.loc[[i]] , ignore_index=True)
          return data_10, data_90
```

```
[39]: def prune_tree(node, attribute, vertex):
          if(node.label is not None):
              return node,0
          elif(node.attribute == attribute and node.vertex == vertex):
              node.children = {}
```

```
        node.attribute = None
        node.label = node.most_common_label

        return node,1
    else:
        for i in node.children:
            a,b = prune_tree(node.children[i], attribute, vertex)

        return node,b
```

```
[40]: def post_pruning(data, node, current_node, children_node, target_attribute):
    if children_node == 0:
        return node
    else:
        for i in current_node.children:
            if current_node.vertex is None:
                #print(i,1)
                post_pruning(data, node, current_node.children[i],␣
↪children_node-1, target_attribute)
            else:
                if current_node.attribute is not None:
                    data10, data90 = get_data_validate(data)
                    #print(current_node.attribute,2)
                    save = copy_tree(current_node)
                    temp_node,c = prune_tree(node, current_node.attribute,␣
↪current_node.vertex)
                    train=data90.drop(target_attribute,axis=1)
                    #print_tree(node,0)
                    temp_node_pred = pred_c45(train, node, target_attribute)
                    #print(temp_node_pred)
                    temp_node_accuracy =␣
↪accuracy(temp_node_pred[target_attribute], data90[target_attribute])
                    #print(temp_node_accuracy)
                    if temp_node_accuracy == 100:
                        post_pruning(data, temp_node, current_node,␣
↪children_node, target_attribute)
                    else :

                        node.addChildren(current_node.vertex, save)
                        #print_tree(node,0)


                        post_pruning(data, node, save.children[i],␣
↪children_node, target_attribute)
        return node
```

0.0.1 ANN

[41]:
```
def sigmoid(x):
    return 1/(1+math.exp(-x))
```

[42]:
```
def sign(x):
    if (x>0.5):
        return 1
    else:
        return 0
```

[43]:
```
def count_error(target, output):
    return 0.5*(target-output)*(target-output)
```

[44]:
```
class Neuron:
    def __init__(self, out=None, w=None, is_used=None, error=None):
        self.out = out
        self.w = []
        self.is_used = is_used
        self.error = 0
        self.deltaW = []

    def set_out(self, out):
        self.out = out

    def get_out(self):
        return self.out

    def add_deltaW(self, value):
        self.deltaW.append(value)

    def get_deltaW(self, index):
        return self.deltaW[index]

    def get_arrdW(self):
        return self.deltaW

    def set_deltaW(self, index, value):
        self.deltaW[index] = value

    def add_w(self, value):
        self.w.append(value)

    def set_w(self, index, value):
        self.w[index] = value

    def get_w(self, index):
```

```
        return self.w[index]

    def get_arrW(self):
        return self.w

    def set_is_used(self, is_used):
        self.is_used = is_used

    def get_is_used(self):
        return self.is_used

    def set_error(self, error):
        self.error = error

    def get_error(self):
        return self.error
```

[45]:

```
x = [Neuron() for i in range (5)]
y = [x for i in range(5)]
```

[46]:

```
def LenCol(arr):
    return len(arr)
def LenRow(inp,hid,out):
    return max(inp,max(hid)+1,out)
def MakeMatrix(row,col):
    return [[Neuron() for i in range (col)] for j in range(row)]
```

[47]:

```
def printMatrixMLP(matrix):
    for i in range(len(matrix)):
        temp_matrix_out = []
        for j in range(len(matrix[i])):
            temp_matrix_out.append(matrix[i][j].get_arrW())
        print(temp_matrix_out)
```

[48]:

```
def convTarget(output,unique):
    res = []
    for i in range(unique):
        if (i!=output):
            res.append(0)
        else:
            res.append(1)
    return res
```

[49]:

```
def resetDeltaWeight(mat,layer):
    for i in range(len(layer)-1):
        for j in range(layer[i]):
```

```
            for k in range(layer[i+1]):
                mat[j][i].set_deltaW(k,0)
```

[50]:
```
def initW(mat,layer):
    for i in range(len(layer)-1):
        for j in range(layer[i]):
            for k in range(layer[i+1]):
                mat[j][i].add_w(np.random.uniform(-1,1))
                mat[j][i].add_deltaW(0)
```

[51]:
```
def feedforward(mat,layer):
    for i in range(1,len(layer)):
        if (i!=len(layer)-1):
            mat[layer[i]][i].set_out(1)
        for j in range(layer[i]):
            net = 0;
            for k in range(layer[i-1]):
                #print(k,i-1,j)
                net = net + mat[k][i-1].get_out()*mat[k][i-1].get_w(j)
#             if (i!=len(layer)-1):
            mat[j][i].set_out(sigmoid(net))
#             else:
#                 mat[j][i].set_out(sign(sigmoid(net)))
```

[52]:
```
def get_error_total(matrix, n_output, target_arr):
    output_col = len(matrix[0])-1
    total_error = 0
    for i in range(n_output):
        total_error += 0.5*(target_arr[i] - matrix[i][output_col].get_out())**2

    return total_error
```

[53]:
```
def set_output_error(matrix, row, col, target_value):
    output_value = matrix[row][col].get_out()
    #print(output_value, target_value)
#     print(output_value * (1 - output_value) * (target_value - output_value))
    matrix[row][col].set_error(output_value * (1 - output_value) *␣
 ↪(target_value - output_value))
```

[54]:
```
def set_hidden_error(matrix, row, col):
    output_value = matrix[row][col].get_out()
    delta_weight_error = 0
    for i in range(len(matrix[row][col].w)):
        delta_weight_error += matrix[row][col].get_w(i) * matrix[i][col+1].
 ↪get_error()
    matrix[row][col].set_error(output_value * (1 - output_value) *␣
 ↪delta_weight_error)
```

[55]:
```
def update_delta_weight(matrix, row, col, idx , learning_rate):
    #print(matrix[i][col+1].get_error(),matrix[row][col].get_out(),row,col)
    #print(row,col+1)
    delta_weight = learning_rate * matrix[row][col].get_error() *␣
↪matrix[idx][col-1].get_out()
    #print(delta_weight)

    current_weight = matrix[idx][col-1].get_deltaW(row)
    matrix[idx][col-1].set_deltaW(row, current_weight + delta_weight)
    #print(idx,col-1,row,current_weight + delta_weight)
```

[56]:
```
def update_weight(mat,layer):
    for i in range(len(layer)-1):
        for j in range(layer[i]):
            for k in range(layer[i+1]):
                curr_weight = mat[j][i].get_w(k)
                delta_weight = mat[j][i].get_deltaW(k)
                mat[j][i].set_w(k,curr_weight + delta_weight)
```

[57]:
```
def backpropagation(matrix, layer, learning_rate, target_arr):
    for i in range(len(layer)-1, 0, -1):
        if i == len(layer)-1:
            for j in range(layer[i]):
                set_output_error(matrix, j, i, target_arr[j])
        else:
            for j in range(layer[i]):
                set_hidden_error(matrix, j, i)
        for j in range(layer[i-1]):
            for k in range(layer[i]):
                update_delta_weight(matrix, k, i, j, learning_rate)
```

[58]:
```
hidden_node = [3,4]
def MLP(data,target, hidden_node, epochs, learning_rate):
    output_node = data[target].nunique()
    input_node = len(data.columns)
    hidden_node.insert(0,input_node)
    hidden_node.append(output_node)
    layer_node = hidden_node
    mlp =␣
↪MakeMatrix(LenRow(input_node,hidden_node,output_node),LenCol(hidden_node))
    initW(mlp,layer_node)
    train = data.drop(target,axis=1)
    batch = len(data)/10;
    for k in range(epochs):
        error = 0
        for i in range(int(batch)):
            for j in range(10):
```

```
                for index,col in enumerate(train.columns):
                    mlp[index][0].set_out(data[col][j+i*10])
                mlp[input_node-1][0].set_out(1)
                feedforward(mlp,layer_node)
                backpropagation(mlp, layer_node, learning_rate,␣
↪convTarget(data[target][j+i*10],output_node))
                error += get_error_total(mlp,␣
↪len(convTarget(data[target][j+i*10],output_node)),␣
↪convTarget(data[target][j+i*10],output_node))
            update_weight(mlp,layer_node)
            resetDeltaWeight(mlp,layer_node)
        print(error)
    print()
    print()
    printMatrixMLP(mlp)

    return mlp,layer_node
```

[59]:
```
def predMyMLP(data, target, model, output_layer):
    out = []
    mlp = model[0]
    for i in range(0,data.shape[0],1):
        for index,col in enumerate(data.columns):
            mlp[index][0].set_out(data[col][i])
        mlp[len(data.columns)-1][0].set_out(1)
        feedforward(mlp,model[1])
        output_col = len(mlp[0])-1
        #print(output_col)
        mx=0
        res=-1
        for j in range(output_layer):
            # print(mlp[j][output_col].get_out())
            if mlp[j][output_col].get_out()>mx:
                mx = mlp[j][output_col].get_out()
                res = j
        # print()
        out.append(res)
    data = { target: data[target],
             'prediction':out}
    return pd.DataFrame(data)
```

1 Testing

[60]:
```
class_list = iris['target'].unique()

# Create confusion matrix from testing result of a model
#
# Input:
#    pandas.DataFrame   prediction_data
#    String             actual_column
#    String             prediction_column
#    Array              class_list
# Output:
#    pandas.DataFrame   confusion_matrix
#
def confusion_matrix(prediction_data, actual_column, prediction_column,␣
↪class_list):
    actual_data = pd.Categorical(prediction_data[actual_column],␣
↪categories=class_list)
    prediction_data = pd.Categorical(prediction_data[prediction_column],␣
↪categories=class_list)
    confusion_matrix = pd.crosstab(actual_data, prediction_data,␣
↪rownames=['Actual'], colnames=['Predicted'], dropna=False)
    return confusion_matrix
```

[61]:
```
# Get accuracy from testing result of a model
#
# Input:
#    pandas.DataFrame   prediction_data
#    String             actual_column
#    String             prediction_column
# Output:
#    float              accuracy
#
def testing_accuracy(prediction_data, actual_column, prediction_column):
    count = 0
    for index, row in prediction_data.iterrows():
        if(row[actual_column] == row[prediction_column]):
            count = count + 1
    return round(count/prediction_data.shape[0],2)
```

[62]:
```
def testing_precision(confusion_matrix):
    conf_matrix = confusion_matrix.to_numpy()
    all_precisions = []

    for idx_col in range(len(conf_matrix[0])):
        true_positive = conf_matrix[idx_col][idx_col]
```

```
        false_positive = 0

        for idx_row in range(len(conf_matrix)):
            if idx_col != idx_row:
                false_positive += conf_matrix[idx_row][idx_col]

        temp_precision = true_positive / (true_positive + false_positive)

        all_precisions.append(temp_precision)

    return sum(all_precisions)/len(all_precisions)
```

[63]:
```
def testing_recall(confusion_matrix):
    conf_matrix = confusion_matrix.to_numpy()
    all_recalls = []

    for idx_row in range(len(conf_matrix)):
        true_positive = conf_matrix[idx_row][idx_row]
        false_negative = 0

        for idx_col in range(len(conf_matrix[0])):
            if idx_col != idx_row:
                false_negative += conf_matrix[idx_row][idx_col]

        temp_recall = true_positive / (true_positive + false_negative)

        all_recalls.append(temp_recall)

    return sum(all_recalls)/len(all_recalls)
```

[64]:
```
def testing_f1(precision, recall):

    return 2*precision*recall/(precision+recall)
```

1.1 Train Test Split

[65]:
```
# Drop index columns
iris_X.drop('index',axis=1,inplace=True);
iris_y.drop('index',axis=1,inplace=True);
```

[66]:
```
# spliting data
X_train, X_test, y_train, y_test = train_test_split(iris_X, iris_y, test_size=0.
↪1, random_state=42)
```

[67]:
```python
# merge data from train test split
# output is train and testing data
def mergeData(X_train, X_test, y_train, y_test):
    X_train = X_train.reset_index()
    y_train = y_train.reset_index()
    X_test = X_test.reset_index()
    y_test = y_test.reset_index()
    trainData = X_train.merge(y_train)
    testData = X_test.merge(y_test)
    trainData.drop("index",axis=1,inplace=True)
    testData.drop("index",axis=1,inplace=True)
    return trainData,testData
```

[68]:
```python
trainData,testData = mergeData(X_train, X_test, y_train, y_test)
```

1.2 DTL

[69]:
```python
# training model
model = c45(trainData, "target",True)
# predict test
prediction_dtl = pred_c45(testData, model, "target")
print(prediction_dtl)
```

```
    target  prediction
0        1           1
1        0           0
2        2           2
3        1           1
4        1           1
5        0           0
6        1           1
7        2           2
8        1           1
9        1           1
10       2           2
11       0           0
12       0           0
13       0           0
14       0           0
```

[70]:
```python
print(confusion_matrix(prediction_dtl,'target','prediction', class_list))
```

```
Predicted  0  1  2
Actual
0          6  0  0
1          0  6  0
```

2   0 0 3

[71]:
```python
testing_accuracy(prediction_dtl,'target','prediction')
```

[71]: 1.0

[72]:
```python
conf_matrix_dtl = confusion_matrix(prediction_dtl,'target','prediction',␣
↪class_list)
```

[73]:
```python
print(testing_precision(conf_matrix_dtl))
precision_dtl = testing_precision(conf_matrix_dtl)
```

1.0

[74]:
```python
print(testing_recall(conf_matrix_dtl))
recall_dtl = testing_recall(conf_matrix_dtl)
```

1.0

[75]:
```python
print(testing_f1(precision_dtl, recall_dtl))
```

1.0

1.3 ANN

[76]:
```python
# training model
hidden_node = [4,4,2]
x = MLP(trainData, 'target', hidden_node,1500,0.1)
```

```
48.456721355679846
45.32696331992125
44.14392528309512
43.71411870171913
43.559554993978715
43.50207822587371
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43.46302453065801
43.45947070696696
43.45683798822838
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43.45276256631283
43.4510067022132
43.449342066746205
43.44772836911882
43.44613603183114
43.44454117431175
```

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[[], [], [], [], []]
```

[77]:
```
# predict
prediction_ann = predMyMLP(testData, 'target', x, 3)
print(prediction_ann)
```

```
    target  prediction
0        1           1
1        0           0
2        2           2
3        1           1
4        1           1
5        0           0
6        1           1
7        2           2
8        1           2
9        1           1
10       2           2
11       0           0
12       0           0
13       0           0
14       0           0
```

[78]:
```
# confusion matrix
conf_matrix_ann = confusion_matrix(prediction_ann,'target','prediction',␣
 ↪class_list)
print(confusion_matrix(prediction_ann,'target','prediction', class_list))
```

```
Predicted  0  1  2
Actual
0          6  0  0
1          0  5  1
2          0  0  3
```

[79]:
```python
# accurcy
testing_accuracy(prediction_ann,'target','prediction')
```

[79]: 0.93

[80]:
```python
print(testing_precision(conf_matrix_ann))
precision_ann = testing_precision(conf_matrix_ann)
```

```
0.9166666666666666
```

[81]:
```python
print(testing_recall(conf_matrix_ann))
recall_ann = testing_recall(conf_matrix_ann)
```

```
0.9444444444444445
```

[82]:
```python
print(testing_f1(precision_ann, recall_ann))
```

```
0.9303482587064678
```

[83]:
```python
iris.describe()
```

[83]:
```
       sepal length (cm)  sepal width (cm)  petal length (cm)  \
count         150.000000        150.000000         150.000000
mean            5.843333          3.057333           3.758000
std             0.828066          0.435866           1.765298
min             4.300000          2.000000           1.000000
25%             5.100000          2.800000           1.600000
50%             5.800000          3.000000           4.350000
75%             6.400000          3.300000           5.100000
max             7.900000          4.400000           6.900000

       petal width (cm)      target
count        150.000000  150.000000
mean           1.199333    1.000000
std            0.762238    0.819232
min            0.100000    0.000000
25%            0.300000    0.000000
50%            1.300000    1.000000
75%            1.800000    2.000000
max            2.500000    2.000000
```

[ ]:
```python

```

1.4 Cross Validation

1.5 DTL

[84]:
```
# make kfold
kf = KFold(n_splits=10,shuffle=True)
```

[85]:
```
accuracy_DTL_KF = []
precisison_DTL_KF = []
recall_DTL_KF = []
f1_DTL_KF = []
for train_index, test_index in kf.split(iris_X):
    X_train, X_test = iris_X.loc[train_index], iris_X.loc[test_index]
    y_train, y_test = iris_y.loc[train_index], iris_y.loc[test_index]
    trainData,testData =  mergeData(X_train, X_test, y_train, y_test)
    # training model
    model = c45(trainData, "target",True)
    # predict
    prediction_dtl = pred_c45(testData, model, "target")
    # measure model from kfold
    conf_matrix_dtl = confusion_matrix(prediction_dtl,'target','prediction',␣
 ↪class_list)
    accuracy_DTL_KF.
 ↪append(testing_accuracy(prediction_dtl,'target','prediction'))
    save_precision = testing_precision(conf_matrix_dtl)
    precisison_DTL_KF.append(save_precision)
    save_recall = testing_recall(conf_matrix_dtl)
    recall_DTL_KF.append(save_recall)
    f1_DTL_KF.append(testing_f1(save_precision, save_recall))
```

[86]:
```
round(np.mean(accuracy_DTL_KF)*100,2)
```

[86]: 94.0

[87]:
```
round(np.mean(precisison_DTL_KF)*100,2)
```

[87]: 94.06

[88]:
```
round(np.mean(recall_DTL_KF)*100,2)
```

[88]: 93.5

[89]:
```
round(np.mean(f1_DTL_KF)*100,2)
```

[89]: 93.77

1.6 ANN

[90]:
```
accuracy_MLP_KF = []
precisison_MLP_KF = []
recall_MLP_KF = []
f1_MLP_KF = []
for train_index, test_index in kf.split(iris_X):
    #print("TRAIN:", train_index, "TEST:", test_index)
    X_train, X_test = iris_X.loc[train_index], iris_X.loc[test_index]
    y_train, y_test = iris_y.loc[train_index], iris_y.loc[test_index]
    trainData,testData =  mergeData(X_train, X_test, y_train, y_test)
    hidden_node = [4,4,2]
    # train
    model = MLP(trainData, 'target', hidden_node,1000,0.1)
    # predict
    prediction_ann = predMyMLP(testData, 'target', x, 3)
    # save accuracy result from kfold
    conf_matrix_ann = confusion_matrix(prediction_ann,'target','prediction',␣
 ↪class_list)
    accuracy_MLP_KF.
 ↪append(testing_accuracy(prediction_ann,'target','prediction'))
    save_precision = testing_precision(conf_matrix_ann)
    precisison_MLP_KF.append(save_precision)
    save_recall = testing_recall(conf_matrix_ann)
    recall_MLP_KF.append(save_recall)
    f1_MLP_KF.append(testing_f1(save_precision, save_recall))
```

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```

[91]:
```
accuracy_MLP_KF
```

[91]: [1.0, 1.0, 0.93, 0.93, 1.0, 1.0, 0.93, 1.0, 1.0, 1.0]

[92]:
```
round(np.mean(f1_MLP_KF)*100,2)
```

[92]: 97.69

[93]:
```
round(np.mean(recall_MLP_KF)*100,2)
```

[93]: 97.75

[94]:
```
round(np.mean(precisison_MLP_KF)*100,2)
```

[94]: 97.67

[95]:
```
round(np.mean(accuracy_MLP_KF)*100,2)
```

[95]: 97.9

1.7 Save and Load

[96]:
```
# this function will create file to save our DTL model
# our model representation will be likely printed tree

def create_file_DTL(node, depth):

    if node.label is not None:
        file.write(" "*(depth+1) +str(node.label))
        file.write('\n')
    else:
        file.write(" "*depth + "["+ node.attribute +"]")
        file.write('\n')
        for i in node.children:
            file.write("----"*(depth+1) +str(i))
            create_file_DTL(node.children[i],depth+1)
```

[97]:
```
# load file txt representation of DTL and return an model as root

def load_file_dtl(parent, depth, file):
    line = file.readline().rstrip()

    while line:
        tabs = line.count('----')

        if tabs < depth:
            break
        else :
            node = Node()
            parsed_line = ''
            vertex = ''

            if depth == 0:
                line = line[1:-1]
                parent.setAttribute(line)

            else:
                if (line[-1] == ']'):
                    parsed_line = line.replace('----', '').split('[')
                    vertex = parsed_line[0].rstrip()
                    attribute = parsed_line[1].strip()[:-1]
                    node.setAttribute(attribute)
                    node.setVertex(vertex)

                else:
                    parsed_line = line.replace('----', '').split(' ' *␣
↪(depth+1))
```

```
                    vertex = parsed_line[0].rstrip()
                    label = parsed_line[1].strip()
                    node.setVertex(vertex)
                    node.setLabel(label)

            parent.children[vertex] = node

            line = load_file_dtl(node, depth + 1, file)

    return line
```

[99]:
```
# save DTL model into file
model = c45(iris, "target",True)
file = open("text_dtl.txt", "w")
create_file_DTL(model, 0)
file.close()
```

[100]:
```
# load DTL model from file
node = Node() # node is a parent node
file = open("text_dtl.txt", "r")

#call the function to load DTL model from file, 0 (depth) represent a root node
load_file_dtl(node, 0 , file)
node.children[''].setAttribute(node.attribute)
node = node.children['']
print_tree(node, 0)
file.close()
```

```
[petal length (cm)]
---->=2.45
    [petal width (cm)]
-------->=1.75
        [sepal width (cm)]
------------>=3.15
            [sepal length (cm)]
---------------->=6.05
                    2
----------------<6.05
                    1
------------<3.15
                2
--------<1.75
        [petal length (cm)]
------------>=4.95
            [petal width (cm)]
---------------->=1.55
                [sepal length (cm)]
```

```
-------------------->=6.95
                        2
--------------------<6.95
                        1
----------------<1.55
                    2
------------<4.95
            [petal width (cm)]
---------------->=1.65
                    2
----------------<1.65
                    1
----<2.45
        0
```

[101]:
```
# this function will create file to save our ANN model
# we save for each line represent a node j on layer i
# for every line we print into file in format; i,j = array_W | array_dW | out |␣
↪error

def create_file_ANN():
    file = open("text_ann.txt", "w")

    for i in range(0,len(x[1])):
        for j in range(0,x[1][i]):
            file.write(str(i));
            file.write(',')
            file.write(str(j));
            file.write('=')
            file.write(str(x[0][i][j].get_arrW()))
            file.write('|')
            file.write(str(x[0][i][j].get_arrdW()))
            file.write('|')
            file.write(str(x[0][i][j].get_out()))
            file.write('|')
            file.write(str(x[0][i][j].get_error()))
            file.write('\n');

    file.close()
```

[102]:
```
# load file txt that contain model representation of ANN

def load_file_ann(file):
    neurons = file.read().split("\n")[:-1]

    rows = []
    columns = []
```

```
    curr_row = 0

    for neuron in neurons:
        neuron_pos = neuron.split('=')[0].split(',')
        if int(neuron_pos[0]) != curr_row:
            rows.append(columns)
            columns = []
            curr_row += 1

        new_neuron = Neuron()
        neuron_elements = neuron.split('=')[1].rstrip().split('|')
        weights = neuron_elements[0]
        delta_weights = neuron_elements[1]
        out = neuron_elements[2]
        err = neuron_elements[3]

        if len(weights) > 2:
            parsed_weights = weights[1:-1].split(',')
            for weight in parsed_weights:
                new_neuron.add_w(float(weight.strip()))

        if len(delta_weights) > 2:
            parsed_delta_weights = delta_weights[1:-1].split(',')
            for delta_weight in parsed_delta_weights:
                new_neuron.add_deltaW(float(delta_weight.strip()))

        new_neuron.set_out(float(out))
        new_neuron.set_error(float(err))

        columns.append(new_neuron)

    max_col_len = max([len(row) for row in rows])
    for row in rows:
        if len(row) < max_col_len:
            for i in range(max_col_len-len(row)):
                row.append(Neuron())

    return rows
```

[103]:
```
# save ANN model into file
create_file_ANN()
```

[104]:
```
# load ANN model from file
file = open("text_ann.txt", "r")
rows = load_file_ann(file)
printMatrixMLP(rows)
```

```
file.close()
```

```
[[-5.006562282470774, -1.141373048555413, 0.9892535474134329,
0.3361251295921864], [-2.6951006135534286, -1.7432078114205836,
5.147018592572216, 0.7250842546828201], [1.3999664875375386,
-3.6928975488678133], [3.242445154294069, -1.9877068823246162,
-21.74739348489987], []]
[[-9.00189769995629, 0.31946033644706734, -0.16781241656238483,
2.2963485037419074], [-0.46129513771118336, 0.6873755241641054,
0.21017950981829767, 0.5036436933867913], [3.8252979189378493,
-4.274252778079346], [-21.489943415461536, -1.8283290681395148,
2.9994582359407365], []]
[[9.59964346143173, -0.6608476968063707, 0.5309998506280069,
-3.713939810552608], [0.9284868796382807, -0.5434414036770522,
-2.264166667137126, 1.8397732792101458], [-3.069931162757634,
6.028772492880621], [], []]
[[11.185182529465825, 0.3093841942047711, -0.2201949144507605,
-0.7994472288924946], [2.2446953944807455, 3.375115187892445, -2.83638021292122,
-4.169156219264595], [], [], []]
```

2 Generate New Instance

[105]:
```
# Generate n instance like iris dataset
# return new n instance as new dataframe
def generateIris(n):
    a = []
    b = []
    c = []
    d = []
    e = []
    for i in range(n):
        a.append(random.uniform(4.5, 7.5))
        b.append(random.uniform(2, 4.4))
        c.append(random.uniform(1, 6.9))
        d.append(random.uniform(0.1, 2.5))
        e.append(1)
    iris = {'sepal length (cm)': a,
            'sepal width (cm)': b,
            'petal length (cm)':c,
            'petal width (cm)':d,
            'target': e
            }
    return pd.DataFrame(iris, columns = ['sepal length (cm)', 'sepal width␣
↪(cm)','petal length (cm)','petal width (cm)','target'])
```

[106]:
```
# Make 100 instance
new_ins = generateIris(100)
```

[107]:
```
# save model
model = c45(iris, "target",True)
file = open("text_dtl.txt", "w")
create_file_DTL(model, 0)
file.close()
```

[108]:
```
# load model
node = Node()
file = open("text_dtl.txt", "r")
load_file_dtl(node, 0 , file)
node.children[''].setAttribute(node.attribute)
node = node.children['']
file.close()
```

[109]:
```
# prediction model
prediction_dtl = pred_c45(new_ins, node, "target")
```

[110]:
```
new_ins['target']=prediction_dtl['prediction']
```

[111]:
```
new_ins['target'].value_counts()
```

[111]:
```
2    55
1    27
0    18
Name: target, dtype: int64
```

3 Analisis

3.0.1 Analisis Data

Dataset iris memiliki target yang yang seimbang yang mana banyaknya 0,1,2 mempunyai porsi yang sama. Range data pada data setiap kolom juga tidak terlalu besar atau bisa dibilang standar deviasi nya kecil. Data ini juga tidak memiliki pencilan

3.0.2 Train test split DTL

- acc = 100
- precision = 100
- recall = 100
- f1 = 100

Train test split cuma 1 kali, Sehingga kemungkinan akan terjadi overfit pada data tertentu. Saat kita mengambil data sebanyak 90 persen sebagai data train. Bisa jadi model yang dibuat sudah bisa memprediksi dengan baik, karena data test 10 persen tersebut tidak terlalu beda dengan data train 90 persen. Hal ini bisa dilihat pada penjelasan Analisis data diatas

Pada hasil eksperimen, nilai Accuracy, Precision, Recall, dan F1 score mirip. Hal ini dikarenakan data yang digunakan (dataset iris) memiliki target yang seimbang

3.0.3 Cross validation DTL

- acc = 92.8
- precision = 92.14
- recall = 93.23
- f1 = 92.67

Model DTL ini cukup overfit. Terbukti saat kami menggunakan cross validation nilai nya lebih kecil jika dibandingkan dengan metode train test split. Karena cross validation ini menggunakan skema train test secara bergantian setiap fold. Solusi, kami menyarankan untuk mengetes setiap model dengan cross validation agar pengukuran lebih akurat

Pada hasil eksperimen, nilai Accuracy, Precision, Recall, dan F1 score mirip. Hal ini dikarenakan data yang digunakan (dataset iris) memiliki target yang seimbang

3.0.4 Train test split ANN

- acc = 93
- precision = 91.6
- recall = 94.4
- f1 = 93.0

Dari hasil eksperimen ini didapatkan nilai Accuracy, Precision, Recall, dan F1 yang lebih kecil dari train test split pada DTL. Hal ini karena pada model ANN didasarkan oleh perkalian bobot dan input untuk menghasilkan output. Sehingga tidak rawan overfit seperti yang terjadi pada DTL

Semakin banyak epoch cenderung lebih bagus. Karena semakin besar epoch yang digunakan nilai error di akhir cenderung lebih kecil. Sebagai contoh, kami pernah melakukan pembelaran dengan epoch 100 mendapatkan akurasi sekitar 30 persen. Dan saat kita menggunakan epoch => 1000 kita mendapatkan nilai akurasi > 90 persen

Selain itu learning rate juga mempegaruhi pengurangan error. Kita harus memiliki nilai learning rate yang tepat. Karena ketika learning rate terlalu tinggi, bisa jadi mengakibatkan model gagal mencapai minimum global untuk fungsi error atau juga bisa terjadi gagal mencapai konvergen. Dan apabila kita memilih learning rate terlalu kecil akan lama mencapai nilai optimum

Dalam pemilihan banyaknya layer dan perceptron setiap layer. Semakin banyak layer dan perceptron setiap layer, semakin sedikit minimum lokal yang terbentuk, sehingga model cenderung dapat mencapai minimum global. Namun ada trade off ketika menggunkan banyak layer dan banyak perceptron, waktu training menjadi lebih lama

Pada hasil eksperimen, nilai Accuracy, Precision, Recall, dan F1 score mirip. Hal ini dikarenakan data yang digunakan (dataset iris) memiliki target yang seimbang

3.0.5 Cross validation ANN

- acc = 97.2
- precision = 97.5
- recall = 96.47
- f1 = 96.92

Dari hasil eksperiman diatas, secara umum model ANN lebih bagus jika dibandingkan dengan DTL untuk data yang cukup

Pada hasil eksperimen, nilai Accuracy, Precision, Recall, dan F1 score mirip. Hal ini dikarenakan data yang digunakan (dataset iris) memiliki target yang seimbang

Catatan : Nilai Accuracy, Precision, Recall, dan F1 score pada setiap eksperimen mungkin berbeda beda setiap kali run program