Assignment 1

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mounting the Google Drive

In [91]:
```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly re
mount, call drive.mount("/content/drive", force_remount=True).
```

importing all the required libraries

In [92]:
```
# import all the necessary libraries here
import pandas as pd
import numpy as np
from collections import Counter
from sklearn.model_selection import train_test_split
from sklearn.metrics import precision_score,balanced_accuracy_score
import matplotlib.pyplot as plt
import graphviz
from IPython.display import Image,display_svg
```

Reading the given data into a dataframe

In [93]:
```
df = pd.read_csv('/content/drive/MyDrive/asssign2/dataset/decision-
attr_names = list(df.columns); attr_names.pop()
print(df.shape)
```

```
(768, 9)
```

In [94]:
```
df.head(10)
```

Out[94]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFun
0	6	148	72	35	0	33.6	
1	1	85	66	29	0	26.6	
2	8	183	64	0	0	23.3	
3	1	89	66	23	94	28.1	
4	0	137	40	35	168	43.1	
5	5	116	74	0	0	25.6	
6	3	78	50	32	88	31.0	
7	10	115	0	0	0	35.3	
8	2	197	70	45	543	30.5	
9	8	125	96	0	0	0.0	

splitting the data into training and validation

In [95]:
```
x_train=np.array(df.iloc[:,:8])
y_train=np.array(df.iloc[:,8])
```

In [96]:
```
x_train.shape
```

Out[96]: (768, 8)

In [97]:
```
y_train.shape
```

Out[97]: (768,)

In [98]:
```
X_train, X_test, y_train, y_test = train_test_split(x_train, y_trai
```

In [99]:
```
a=X_train.shape
c=X_test.shape
print("The size of train data is ",a)
print("The size of test data is ",c)
```

```
The size of train data is  (614, 8)
The size of test data is  (154, 8)
```

In [100]:
```
a=len(y_train)
c=len(y_test)
print("The size of train data is ",a)
print("The size of test data is ",c)
```

```
The size of train data is  614
The size of test data is  154
```

Implementation of entropy function

In [101]:
```
def entropy(targets):
    label_counts = Counter(targets)
    entropy = 0
    total_labels = len(targets)

    for label, count in label_counts.items():
        prob = count / total_labels
        entropy -= prob * np.log2(prob)

    return entropy
```

partititon of data into left subtree and right subtree

In [102]:
```
def partition(data,attr,target,value):
  m = data.shape[0]
  left_split = [data[i] for i in range(m) if data[i][attr]<value]
  left_split = np.array(left_split)
  targets_l = [target[i] for i in range(m) if data[i][attr]<value]
  targets_l = np.array(targets_l)
  right_split = [data[i]for i in range(m) if data[i][attr]>=value]
  right_split = np.array(right_split)
  targets_r = [target[i]for i in range(m) if data[i][attr]>=value]
  targets_r = np.array(targets_r)
  return left_split,right_split,targets_l,targets_r
```

Implementation of choosing the best attribute at a given node

In [103]:
```
def best_attr(data,target,attrs):
    total_entropy = entropy(target)
    m = data.shape[0]
    n = data.shape[1]
    entropies = [total_entropy for i in range(n) ]
    break_pt = [0 for i in range(n)]
    best_attr = attrs[0]

    for attr in attrs:
      attribute_values = list(set(data[:,attr]))
      attribute_values.sort()
      break_pt[attr] = attribute_values[0]-1
      for i in range(1,len(attribute_values)):
        curr_entropy= 0
        curr_val = (attribute_values[i-1]+attribute_values[i])/2
        l_data, r_data,l_targets,r_targets = partition(data,attr,ta
        w1 = l_data.shape[0]/m
        w2 = r_data.shape[0]/m
        curr_entropy += w1*entropy(l_targets)
        curr_entropy += w2*entropy(r_targets)
        if(curr_entropy < entropies[attr]):
          break_pt[attr] = curr_val
          entropies[attr] = curr_entropy
      if entropies[attr] < entropies[best_attr]:
         best_attr = attr

    return best_attr,break_pt[best_attr],entropies[best_attr]
```

Definition of Node

In [104]:
```
class Node:
    def __init__(self,flag,label,attr,val,children,count):
        self.flag = flag
        self.label = label
        self.attr = attr
        self.val = val
        self.children = [0,0]
        self.count=count
```

Definition of Node Function and all the required functions for pruning and results

In [105]:
```
class DecisionTree:
  def __init__(self,dt):
    self.root = dt
  def decision(self,node,sample):
    if(node.flag==1):
      return node.label
    if(sample[node.attr]<node.val):
      return self.decision(node.children[0],sample)
    return self.decision(node.children[1],sample)
```

```
def take_decision(self,data):
  pred=[]
  m = data.shape[0]
  for i in range(m):
    pred.append(self.decision(self.root,data[i]))
  return pred

def copy_DT(self,node):
      newnode = Node(node.flag,node.label,node.attr,node.val,node
      if(newnode.flag==0):
          newnode.children[0] = self.copy_DT(node.children[0])
          newnode.children[1] = self.copy_DT(node.children[1])
      return newnode

def copy_dt(self):
      newdt = DecisionTree(self.copy_DT(self.root))
      return newdt

def getAccuracy(self,data_test,true_data):
      prediction = self.take_decision(data_test)
      return balanced_accuracy_score(true_data,prediction)

def getMacroPrecision(self,data_test,true_data):
      prediction = self.take_decision(data_test)
      return precision_score(true_data,prediction,average="macro"

def getMacroRecall(self,data_test,true_data):
      prediction = self.take_decision(data_test)
      return recall_score(true_data,prediction,average="macro")

def printMetrics(self,data_test,true_data,name):
      metrics = [self.getAccuracy(data_test,true_data),self.getMa
      print(f"---> {name} <---")
      print(f"Mean Macro Accuracy: {metrics[0]}")
      print(f"Macro Precision: {metrics[1]}")
      print(f"Macro Recall: {metrics[2]}")


def _maxDepth(self,node,depth):
      if(node.flag==1):
          return depth
      return max(self._maxDepth(node.children[0],depth+1),self._m

def maxDepth(self):
      return self._maxDepth(self.root,1)

def _visualise(self,dot,node,count,parent):
      node_count = count[0]
      count[0] += 1
      if(node.flag==0):
          dot.node(str(node_count),f"{attr_names[node.attr]}\n{no
          dot.edge(str(parent),str(node_count))
          self._visualise(dot,node.children[0],count,node_count)
          self._visualise(dot,node.children[1],count,node_count)
```

```
        else:
            dot.node(str(node_count),f"Label = {node.label}")
            dot.edge(str(parent),str(node_count))

    def visualise(self,name):
        count =[1]
        dot = graphviz.Digraph(name, comment=name)
        dot.node('0',f"Data")
        self._visualise(dot,self.root,count,0)
        return dot

    def visualiseAndSave(self,name):
        dot = self.visualise(name)
        dot.render(name, format="png", cleanup=True)
        print(f"Saved as ",end="")
        image_path = f'./{name}.png'
        print(image_path)
        return dot
```

Creating the tree recursively

In [106]:

```
def create_tree(data,target,attributes):
    curr_entropy = entropy(target)
    best_attribute,brk_pt,new_entropy = best_attr(data,target,attribu
    l_data,r_data,l_target,r_target = partition(data,best_attribute,t
    new_attributes=list(attributes)
    counter = Counter(target)
    count=[Counter[0],Counter[1]]
    if counter[0]>counter[1]:
        max = 0
    else :
        max = 1
    dt = Node(1,max,best_attribute,brk_pt,[0,0],count)
    if(new_entropy<curr_entropy and data.shape[0]>=10 and len(new_att
        dt.flag=0
        dt.children[0] = create_tree(l_data,l_target,attributes)
        dt.children[1] = create_tree(r_data,r_target,attributes)
    return dt
```

creating the instance of root and decision tree

In [107]:

```
attributes = [0,1,2,3,4,5,6,7]
root = create_tree(X_train, y_train, attributes)
Dec_tree = DecisionTree(root)
```

metrics on test dataset before pruning

In [108]:
```
Dec_tree.printMetrics(X_test,y_test,"testing data")
```

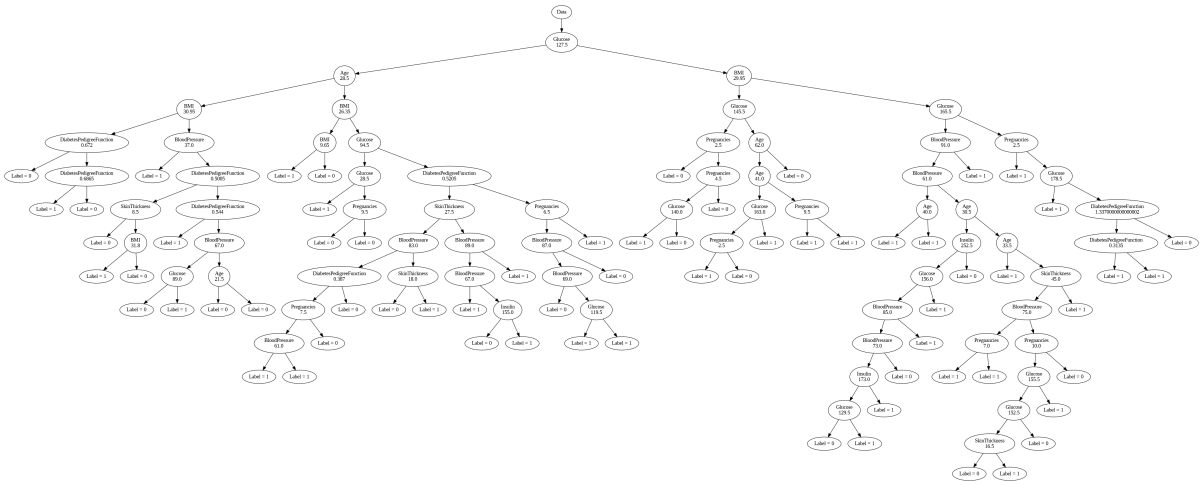
```
---> testing data <---
Mean Macro Accuracy: 0.7202020202020202
Macro Precision: 0.7125886524822695
Macro Recall: 0.7202020202020202
```

visulaisation of decision tree before pruning

In [109]:
```
dot = Dec_tree.visualiseAndSave("Decision_Tree")
print("Trained Decision Tree")
Image(filename="./Decision_Tree.png")
```

```
Saved as ./Decision_Tree.png
Trained Decision Tree
```

Out[109]:



implementation of pruning for a node

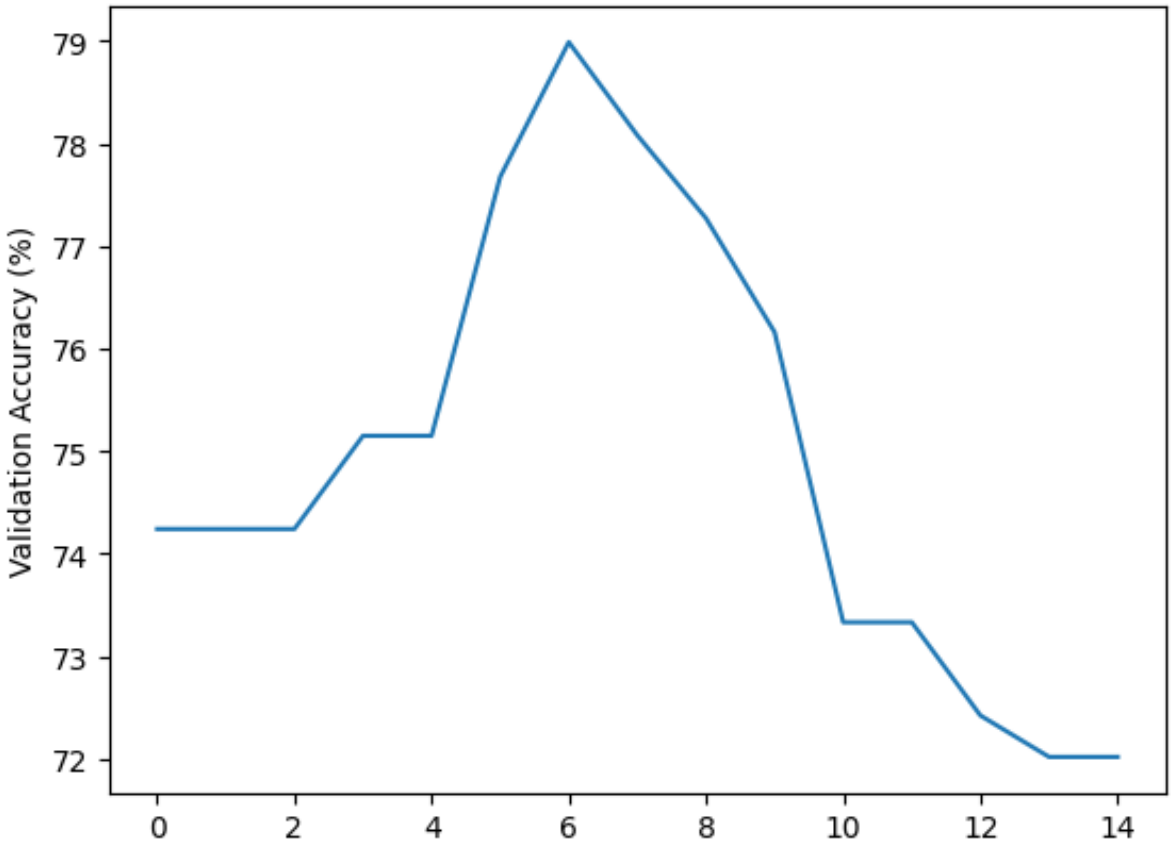
In [110]:

```
def prune(curr_dt,node,depth,depth_limit):
    if(node.flag==1):
        return

    if(depth<depth_limit):
        prune(curr_dt,node.children[0],depth+1,depth_limit)
        prune(curr_dt,node.children[1],depth+1,depth_limit)
        return

    node_copy = Node(node.flag,node.label,node.attr,node.val,node.c
    node_copy.children[0] = node.children[0]; node_copy.children[1]


    accuracy_bef_pruning = curr_dt.getAccuracy(X_test,y_test)

    node.flag = 1
    node.children[0] = node.children[1] = None

    accuracy_after_pruning = [0,0]
    node.label = 0
    accuracy_after_pruning[0] = curr_dt.getAccuracy(X_test,y_test)

    node.label = 1
    accuracy_after_pruning[1] = curr_dt.getAccuracy(X_test,y_test)

    best_label = 0 if(accuracy_after_pruning[0]>accuracy_after_prun

    if(accuracy_after_pruning[best_label] >= accuracy_bef_pruning):
        node.label = best_label
        return

    node.flag = node_copy.flag
    node.label = node_copy.label
    node.children[0] = node_copy.children[0]; node.children[1] = no
    prune(curr_dt,node.children[0],depth+1,depth_limit)
    prune(curr_dt,node.children[1],depth+1,depth_limit)
    return
```

setting the depth limits for getting the best pruning result

In [111]:

```
x_points = []
y_points = []
decision_trees = []
best_depth = 0

max_Depth = Dec_tree.maxDepth()

for depth_limit in range(0,max_Depth+1):
    newdt = Dec_tree.copy_dt()
    prune(newdt,newdt.root,0,depth_limit)
    x_points.append(depth_limit)
    prediction = newdt.take_decision(X_test)
    y_points.append(balanced_accuracy_score(y_test,prediction))
    best_depth = depth_limit if(y_points[depth_limit] > y_points[be

    decision_trees.append(newdt.visualise(f"Decision_Tree[{depth_li



y_points = [i*100 for i in y_points]
plt.plot(x_points,y_points)
plt.xlabel("Pruning Depth")
plt.ylabel("Validation Accuracy (%)")
plt.show()

pruned_dt = Dec_tree.copy_dt()
prune(pruned_dt,pruned_dt.root,0,best_depth)
print(f"Best Accuracy Achieved by pruning nodes with depth between
print("Best Possible Accuracy:",pruned_dt.getAccuracy(X_test,y_test
```



Pruning Depth

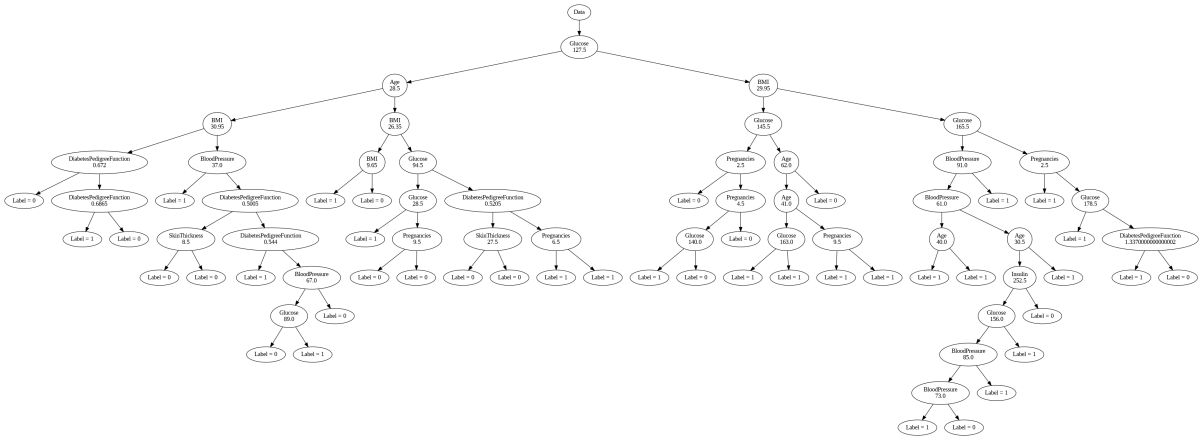
```
Best Accuracy Achieved by pruning nodes with depth between "6" and
"14"
Best Possible Accuracy: 0.7898989898989899
```

visualisation of pruned Decision tree

In [112]:
```
dot = pruned_dt.visualiseAndSave("Pruned_DT")
print("Best Accuracy Decision Tree")
Image(filename='./Pruned_DT.png')
```

```
Saved as ./Pruned_DT.png
Best Accuracy Decision Tree
```

Out[112]:



Metrics for pruned decision tree

In [90]:
```
pruned_dt.printMetrics(X_test,y_test,"Pruned Tree Metrics")
```

```
---> Pruned Tree Metrics <---
Mean Macro Accuracy: 0.7898989898989899
Macro Precision: 0.7753357753357754
Macro Recall: 0.7898989898989899
```