S.E.A.COLLEGE OF ENGINEERING & TECHNOLOGY,
Bengaluru-560049

Department of Computer Science and Engineering &

Information Science and Engineering

BE - VII SEMESTER

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING LABORATORY

18CSL76

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1. Implement A* Search Algorithm.

Program :

```
class Node():
    """A node class for A* Pathfinding"""

    def __init__(self, parent=None, position=None):
        self.parent = parent
        self.position = position

        self.g = 0
        self.h = 0
        self.f = 0

    def __eq__(self, other):
        return self.position == other.position
# Simulate poping from a priority queue. The node  with least f value is popped from queue

def pop_queue(que):

# Get the current node
        current_node = que[0]
        current_index = 0
        for index, item in enumerate(que):
            if item.f < current_node.f:
                current_node = item
                current_index = index

        # Pop current off open list, add to closed list
        return que.pop(current_index)
def astar(maze, start, end):
    """Returns a list of tuples as a path from the given start to the given end in the given maze"""

    # Create start and end node
    start_node = Node(None, start)
    start_node.g = start_node.h = start_node.f = 0
    end_node = Node(None, end)
    end_node.g = end_node.h = end_node.f = 0

    # Initialize both open and closed list
    open_list = []
    closed_list = []

    # Add the start node
    open_list.append(start_node)

    # Loop until you find the end
    while len(open_list) > 0:

        current_node = pop_queue(open_list)
        closed_list.append(current_node)

        # Found the goal
        if current_node == end_node:
            path = []
            current = current_node
            while current is not None:
                path.append(current.position)
                current = current.parent
            return path[::-1] # Return reversed path
```

```
# Generate children
children = []
for new_position in [(0, -1), (0, 1), (-1, 0), (1, 0), (-1, -1), (-1, 1), (1, -1), (1, 1)]: # Adjacent squares

    # Get node position
    node_position = (current_node.position[0] + new_position[0], current_node.position[1] + new_position[1])

    # Make sure within range
    if node_position[0] > (len(maze) - 1) or node_position[0] < 0 or node_position[1] >
    (len(maze[len(maze)-1]) -1) or node_position[1] < 0:
        continue

    # Make sure walkable terrain
    if maze[node_position[0]][node_position[1]] != 0:
        continue

    # Create new node
    new_node = Node(current_node, node_position)

    # Append
    children.append(new_node)

# Loop through children
for child in children:

    # if Child is on the closed list, skip it
    child_in_closed = False
    for closed_child in closed_list:
        if child == closed_child:
                child_in_closed = True
                break
        if child_in_closed:
                continue

        # Create the f, g, and h values
        child.g = current_node.g + 1

        dx = abs(child.position[0] - end_node.position[0])
        dy = abs(child.position[1] - end_node.position[1])
        D = 1  # distance to next horizontal/vertical node
        D2 = 1 # distance to next diagonal node

        child.h = D * (dx + dy) + (D2 - 2 * D) * min(dx, dy)
        #child.h = ((child.position[0] - end_node.position[0]) ** 2) + ((child.position[1] - end_node.position[1]) ** 2)
        child.f = child.g + child.h

        # Child is already in the open list
        discard_child = False
        for open_node in open_list:
            if child == open_node:
                if child.g < open_node.g:
                    open_node.g = child.g
                    open_node.f = open_node.g + open_node.h
                    open_node.parent = current_node
                discard_child = True
                break
```

```python
                # Add the child to the open list
                if discard_child == False:
                    open_list.append(child)


def main():

    maze = [[0, 0, 0, 0, 1, 0, 0, 0, 0, 0],
            [0, 0, 0, 0, 1, 0, 0, 0, 0, 0],
            [0, 0, 0, 0, 1, 0, 0, 0, 0, 0],
            [0, 0, 0, 0, 1, 0, 1, 0, 0, 0],
            [0, 0, 0, 0, 1, 0, 0, 0, 0, 0],
            [0, 0, 0, 0, 0, 0, 1, 0, 0, 0],
            [0, 0, 0, 0, 1, 0, 1, 0, 0, 0],
            [0, 0, 0, 0, 1, 0, 1, 0, 0, 0],
            [0, 0, 0, 0, 1, 0, 1, 0, 0, 0],
            [0, 0, 0, 0, 0, 0, 0, 0, 0.2, 0]]

    start = (0, 0)
    end = (0, 9)

    path = astar(maze, start, end)
    print(path)


if __name__ == '__main__':
    main()
```

Output :

```
[(0, 0), (1, 1), (2, 2), (3, 3), (4, 3), (5, 4), (4, 5), (4, 6), (3, 7), (2, 7), (1, 8), (0, 9)]
```

```python
a = (1,2)
b = (1,2)
if a==b:
    print("Same")
```

Output :

```
Same
```

2. Implement AO* Search Algorithm.

Program :

```
class Node:
    def __init__(self, index,cost,visited=False,is_solved=False,and_map=False, or_map=False):
        self.index=index
        self.cost=cost
        self.visited=visited
        self.is_solved=is_solved
        self.and_map= and_map
        self.or_map = or_map
        self.children=()

    def __str__(self):
        return f'{self.index}: {self.cost}'

    def set_children(self,ch):
        self.children=ch
```

```
adj=[]
n_nodes = 21
#heuristic costs
cost=[None,0,40,2,4,1,2,3,50,60,70,80,4,5,8,9,6,7,90,90,90,90]
and_edges={}
for i in range(n_nodes+1):
    n=Node(i, cost[i])
    adj.append(n)

adj[1].set_children((adj[2],adj[3],adj[4]))
adj[2].set_children((adj[5],adj[6],adj[7]))
adj[3].set_children((adj[8],adj[9]))
adj[4].set_children((adj[10],adj[11]))
adj[5].set_children((adj[12],adj[13])); adj[6].set_children((adj[14],adj[15]))
adj[7].set_children((adj[16],adj[17])); adj[8].set_children((adj[18],))
adj[9].set_children((adj[19],)); adj[10].set_children((adj[20],)); adj[11].set_children((adj[21],))

and_edges[adj[1]] = (adj[3],adj[4])
adj[3].and_map = adj[4].and_map = True

and_edges[adj[2]] = (adj[5],adj[6], adj[7])
adj[5].and_map = adj[6].and_map = adj[7].and_map=True

for a in adj:
    if len(a.children)==0: a.is_solved=True
    if a.and_map==False: a.or_map=True
    #print(f'{a.index} and {a.and_map} or {a.or_map}')
```

```python
def get_key(and_edges, c):
    for idx, ae in and_edges.items():
        if c in ae: return idx, ae
```

```python
def explore_head(head):
    print(f'Head: {head.index}, Cost: {head.cost}')
    head.visited=True; temp_cost = MAX; temp_map={}
    for c in head.children:
        if temp_map.get(c,False): continue;

        if c.and_map: # if the child is in the and edge
            temp_solved=True
           #calculate the cost and check if there are more nodes in the and edge
            idx,ae = get_key(and_edges,c)
            cc=0
            for aek in ae:
                cc+=aek.cost+EDGE
                temp_map[aek]=True
                temp_solved=temp_solved and aek.is_solved
            temp_cost = min(temp_cost,cc)

            if temp_solved:
                head.is_solved=True

        else: # else if child is in the or edge
            temp_cost = min(temp_cost,c.cost+EDGE)
            temp_map[c]=True
            if c.is_solved: head.is_solved=True
    #head is explored now update the best value of head i.e. temp_cost
    if temp_cost < MAX:
        head.cost=temp_cost
        print(f'Updated head cost {head.cost}')
```

```python
def find_best_move(head):
     #find the best move
        isAnd=False
        bestCost=MAX;bestMove=None; bestAndIndex=-1
        temp_map1={}
        for c in head.children:
            if temp_map1.get(c,False):continue

            if c.or_map:
                if bestCost>c.cost+EDGE:
                    bestCost = c.cost+EDGE
                    bestMove=c; isAnd=False
                    temp_map1[c]=True
                print(f'or edge {c.index}, {bestCost}')
            else:
                cc=0
                idx,ae = get_key(and_edges,c)
                for aek in ae:
                    cc+=aek.cost+EDGE
                    temp_map1[aek]=True
                    print(f'and-pair {idx.index}-{c.index}')

                print(f'bestCost {bestCost} cc {cc}')
                if bestCost>cc and cc!=0:
                    bestCost = cc; bestAndIndex = idx; bestMove = c
                    isAnd=True
```

```
      print(f'\nmoving forward, finding the best move,i>>{c.index}')
      if isAnd:
          print(f'and edge, cost: {bestCost}')
      else:
          print(f'or edge, cost: {bestCost}')

  if isAnd:
      for ae in and_edges[bestAndIndex]:
          print(f'isAnd: {isAnd} and, aoStarUtil {ae.index}')
          aostarUtil(ae)
  else:
      print(f'isAnd: {isAnd} or, aoStarUtil {bestMove.index}')
      aostarUtil(bestMove)
def check_update(head):
    temp_cost=MAX; temp_map={}
    for c in head.children:
        if temp_map.get(c,False):continue
        if c.or_map:
            if c.is_solved: head.is_solved=True
            temp_cost= min(temp_cost, c.cost+EDGE)
            temp_map[c]=True
        elif c.and_map:
            f=True;cc=0
            idx,ae = get_key(and_edges,c)
            for aek in ae:
                f = f and aek.is_solved
                cc+=aek.cost+EDGE
                temp_map[aek]=True

            temp_cost = min(temp_cost,cc)
            print(f'temp_cost=min({temp_cost},{cc})')

            if f:
                head.is_solved=True
                break

    if temp_cost<=MAX:
        head.cost = temp_cost

    print(f'Updated Cost of node {head.index} {head.cost}')
def aostarUtil(head):
    if head.visited ==False:
        explore_head(head)
    else:
        find_best_move(head)
        #check if any of the options were solved
        #if there are multiple solved nodes , select the best out of them
        #also update the current cost i.e. head cost while backtracking to the root
        check_update(head)
def aostar(head):
    iter = 0
    while head.is_solved==False and iter <MAX:
        print(f'\n  **Iteration {iter}')
        aostarUtil(head)
        iter+=1
    for a in adj:
        print(a.index,': ',a.cost, end=" ")
```

```python
MAX=1000
EDGE=5 #g cost of edge
aostar(adj[1])
```

Output :

```
  **Iteration 0
Head: 1, Cost: 0
Updated head cost 16

  **Iteration 1
or edge 2, 45

moving forward, finding the best move,i>>2
or edge, cost: 45
and-pair 1-3
and-pair 1-3
bestCost 45 cc 16

moving forward, finding the best move,i>>3
and edge, cost: 16
isAnd: True and, aoStarUtil 3
Head: 3, Cost: 2
Updated head cost 55
isAnd: True and, aoStarUtil 4
Head: 4, Cost: 4
Updated head cost 75
temp_cost=min(45,140)
Updated Cost of node 1 45

  **Iteration 2
or edge 2, 45

moving forward, finding the best move,i>>2
or edge, cost: 45
and-pair 1-3
and-pair 1-3
bestCost 45 cc 140

moving forward, finding the best move,i>>3
or edge, cost: 45
isAnd: False or, aoStarUtil 2
Head: 2, Cost: 40
Updated head cost 21
temp_cost=min(26,140)
Updated Cost of node 1 26

  **Iteration 3
or edge 2, 26

moving forward, finding the best move,i>>2
or edge, cost: 26
and-pair 1-3
and-pair 1-3
bestCost 26 cc 140

moving forward, finding the best move,i>>3
or edge, cost: 26
isAnd: False or, aoStarUtil 2
and-pair 2-5
and-pair 2-5
and-pair 2-5
bestCost 1000 cc 21
```

```
moving forward, finding the best move,i>>5
and edge, cost: 21
isAnd: True and, aoStarUtil 5
Head: 5, Cost: 1
Updated head cost 9
isAnd: True and, aoStarUtil 6
Head: 6, Cost: 2
Updated head cost 13
isAnd: True and, aoStarUtil 7
Head: 7, Cost: 3
Updated head cost 11
temp_cost=min(48,48)
Updated Cost of node 2 48
temp_cost=min(53,140)
Updated Cost of node 1 53
0 :  None 1 :  53 2 :  48 3 :  55 4 :  75 5 :  9 6 :  13 7 :  11 8 :  50 9 :  60 10 :  70 11 :  80 12 :  4 13 :  5 14 :  8 15 :
9 16 :  6 17 :  7 18 :  90 19 :  90 20 :  90 21 :  90
```

3. **For a given set of training data examples stored in a .CSV file, implement and demonstrate the Candidate-Elimination algorithm to output a description of the set of all Hypotheses consistent with the training examples.**

Program:

```
import csv
a = []
print("\n The Given Training Data Set \n")
with open('data1.csv', 'r') as csvFile:
    reader = csv.reader(csvFile)
    for row in reader:
        a.append (row)
        print(row)
num_attributes = len(a[0])-1 # we don't want last col which is target concet ( yes/no)
print("\n The initial value of hypothesis: ")
S = ['0'] * num_attributes
G = ['?'] * num_attributes
print ("\n The most specific hypothesis S0 : [0,0,0,0,0,0]\n")
print (" \n The most general hypothesis G0 : [?,?,?,?,?,?]\n")
for j in range(0,num_attributes):
       S[j] = a[0][j];
# Comparing with Remaining Training Examples of Given Data Set
print("\n Candidate Elimination algorithm  Hypotheses Version Space Computation\n")
temp=[]
for i in range(0,len(a)):
    if a[i][num_attributes]=='1':
        for j in range(0,num_attributes):
            if a[i][j]!=S[j]:
                S[j]='?'
        for j in range(0,num_attributes):
            for k  in range(0,len(temp)):
                if temp[k][j] != '?' and temp[k][j] != S[j]:
                    del temp[k] #remove it if it's not matching with the specific hypothesis
        print(" For Training Example No :{0} the hypothesis is S{0}  ".format(i+1),S)
        if (len(temp)==0):
            print(" For Training Example No :{0} the hypothesis is G{0} ".format(i+1),G)
        else:
            print(" For Training Example No :{0} the hypothesis is G{0}".format(i+1),temp)
   if a[i][num_attributes]=='0':
        for j in range(0,num_attributes):
             if S[j] != a[i][j] and S[j]!= '?':  #if not  matching with the specific Hypothesis
                 G[j]=S[j]
                 temp.append(G) # this is the version space to store all Hypotheses
                 G = ['?'] * num_attributes
        print(" For Training Example No :{0} the hypothesis is S{0} ".format(i+1),S)
        print(" For Training Example No :{0} the hypothesis is G{0}".format(i+1),temp)
```

Dataset to be considered is as follows:-

sunny	warm	normal	strong	warm	same	1
sunny	warm	high	strong	warm	same	1
rainy	cold	high	strong	warm	change	0
sunny	warm	high	strong	cool	change	1

The output is as follows:-

```
 The Given Training Data Set

['sunny', 'warm', 'normal', 'strong', 'warm', 'same', '1']
['sunny', 'warm', 'high', 'strong', 'warm', 'same', '1']
['rainy', 'cold', 'high', 'strong', 'warm', 'change', '0']
['sunny', 'warm', 'high', 'strong', 'cool', 'change', '1']

 The initial value of hypothesis:

 The most specific hypothesis S0 : [0,0,0,0,0,0]


 The most general hypothesis G0 : [?,?,?,?,?,?]


 Candidate Elimination algorithm  Hypotheses Version Space Computation

 For Training Example No :1 the hypothesis is S1   ['sunny', 'warm', 'normal', 'strong',
'warm', 'same']
 For Training Example No :1 the hypothesis is G1  ['?', '?', '?', '?', '?', '?']
 For Training Example No :2 the hypothesis is S2   ['sunny', 'warm', '?', 'strong',
'warm', 'same']
 For Training Example No :2 the hypothesis is G2  ['?', '?', '?', '?', '?', '?']
 For Training Example No :3 the hypothesis is S3  ['sunny', 'warm', '?', 'strong',
'warm', 'same']
 For Training Example No :3 the hypothesis is G3 [['sunny', '?', '?', '?', '?', '?'],
['?', 'warm', '?', '?', '?', '?'], ['?', '?', '?', '?', '?', 'same']]
 For Training Example No :4 the hypothesis is S4   ['sunny', 'warm', '?', 'strong', '?',
'?']
 For Training Example No :4 the hypothesis is G4 [['sunny', '?', '?', '?', '?', '?'],
['?', 'warm', '?', '?', '?', '?']]
```

4. **Write a program to demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.**

Program:

```
import pandas as pd
from pandas import DataFrame
df_tennis= DataFrame.from_csv('data3.csv')
print(df_tennis)
def entropy(probs):
    import math
    return sum([-prob*math.log(prob,2) for prob in probs])

def entropy_of_list(a_list):
    from collections import Counter
    cnt=Counter(x for x in a_list)
    print("NO AND YES CLASSES: ",a_list.name,cnt)
    num_instances=len(a_list)*1.0
    probs=[x/num_instances for x in cnt.values()]
    return entropy(probs)
total_entropy=entropy_of_list(df_tennis['Target'])
print("ENTROPY OF GIVEN PLAYTENNIS DATA SET : ",total_entropy)

def information_gain(df,split_attribute_name,target_attribute_name,trace=0):
    print("INFORMATION GAIN CALCULATION OF ",split_attribute_name)
    df_split=df.groupby(split_attribute_name)
    for name,group in df_split:
        print(name)
        print(group)
    nobs=len(df.index)*1.0
    df_agg_ent=df_split.agg({target_attribute_name: [entropy_of_list, lambda x: len(x)/nobs]})[target_attribute_name]
    df_agg_ent.columns=['Entropy','PropObservations']
    new_entropy=sum(df_agg_ent['Entropy']*df_agg_ent['PropObservations'])
    old_entropy=entropy_of_list(df[target_attribute_name])
    return (old_entropy-new_entropy)

print("INFO-GAIN FOR OUTLOOK IS : "+str(information_gain(df_tennis,'Outlook','Target')),"\n")
print("INFO-GAIN FOR HUMIDITY IS : "+str(information_gain(df_tennis,'Humidity','Target')),"\n")
print("INFO-GAIN FOR WIND IS : "+str(information_gain(df_tennis,'Wind','Target')),"\n")
print("INFO-GAIN FOR TEMPERATURE IS : "+str(information_gain(df_tennis,'Temperature','Target')),"\n")
```

The dataset to be considered is as follows :-

Outlook	Temperat	Humidity	Wind	Target
sunny	hot	high	weak	no
sunny	hot	high	strong	no
overcast	hot	high	weak	yes
rain	mild	high	weak	yes
rain	cool	normal	weak	yes
rain	cool	normal	strong	no
overcast	cool	normal	strong	yes
sunny	mild	high	weak	no
sunny	cool	normal	weak	yes
rain	mild	normal	weak	yes
sunny	mild	normal	strong	yes
overcast	mild	high	strong	yes
overcast	hot	normal	weak	yes
rain	mild	high	strong	no

The output is:

```
         Temperature Humidity    Wind Target
Outlook
sunny            hot     high    weak     no
sunny            hot     high  strong     no
overcast         hot     high    weak    yes
rain            mild     high    weak    yes
rain            cool   normal    weak    yes
rain            cool   normal  strong     no
overcast        cool   normal  strong    yes
sunny           mild     high    weak     no
sunny           cool   normal    weak    yes
rain            mild   normal    weak    yes
sunny           mild   normal  strong    yes
overcast        mild     high  strong    yes
overcast         hot   normal    weak    yes
rain            mild     high  strong     no
NO AND YES CLASSES:  Target Counter({'yes': 9, 'no': 5})
ENTROPY OF GIVEN PLAYTENNIS DATA SET :  0.9402859586706309
```

```
INFORMATION GAIN CALCULATION OF  Outlook
overcast
        Temperature Humidity    Wind Target
Outlook
overcast        hot     high    weak    yes
overcast       cool   normal  strong    yes
overcast       mild     high  strong    yes
overcast        hot   normal    weak    yes
rain
        Temperature Humidity    Wind Target
Outlook
rain           mild     high    weak    yes
rain           cool   normal    weak    yes
rain           cool   normal  strong     no
rain           mild   normal    weak    yes
rain           mild     high  strong     no
sunny
        Temperature Humidity    Wind Target
Outlook
sunny           hot     high    weak     no
sunny           hot     high  strong     no
sunny          mild     high    weak     no
sunny          cool   normal    weak    yes
sunny          mild   normal  strong    yes
NO AND YES CLASSES:  Target Counter({'yes': 4})
NO AND YES CLASSES:  Target Counter({'yes': 3, 'no': 2})
NO AND YES CLASSES:  Target Counter({'no': 3, 'yes': 2})
NO AND YES CLASSES:  Target Counter({'yes': 9, 'no': 5})
INFO-GAIN FOR OUTLOOK IS : 0.2467498197744391

 INFORMATION GAIN CALCULATION OF  Humidity
  high
         Temperature Humidity    Wind Target
 Outlook
 sunny           hot     high    weak     no
 sunny           hot     high  strong     no
 overcast        hot     high    weak    yes
 rain           mild     high    weak    yes
 high
         Temperature Humidity    Wind Target
 Outlook
 sunny          mild     high    weak     no
 overcast       mild     high  strong    yes
 rain           mild     high  strong     no
 normal
         Temperature Humidity    Wind Target
 Outlook
 rain           cool   normal    weak    yes
 rain           cool   normal  strong     no
 overcast       cool   normal  strong    yes
 sunny          cool   normal    weak    yes
 rain           mild   normal    weak    yes
 sunny          mild   normal  strong    yes
 overcast        hot   normal    weak    yes
 NO AND YES CLASSES:  Target Counter({'yes': 2, 'no': 2})
 NO AND YES CLASSES:  Target Counter({'no': 2, 'yes': 1})
 NO AND YES CLASSES:  Target Counter({'yes': 6, 'no': 1})
 NO AND YES CLASSES:  Target Counter({'yes': 9, 'no': 5})
 INFO-GAIN FOR HUMIDITY IS : 0.1619576049392195
```

```
INFORMATION GAIN CALCULATION OF  Wind
strong
          Temperature Humidity   Wind Target
Outlook
sunny             hot     high  strong     no
rain             cool   normal  strong     no
overcast         cool   normal  strong    yes
sunny            mild   normal  strong    yes
overcast         mild     high  strong    yes
rain             mild     high  strong     no
weak
          Temperature Humidity  Wind Target
Outlook
sunny             hot     high  weak     no
overcast          hot     high  weak    yes
rain             mild     high  weak    yes
rain             cool   normal  weak    yes
sunny            mild     high  weak     no
sunny            cool   normal  weak    yes
rain             mild   normal  weak    yes
overcast          hot   normal  weak    yes
NO AND YES CLASSES:  Target Counter({'yes': 3, 'no': 3})
NO AND YES CLASSES:  Target Counter({'yes': 6, 'no': 2})
NO AND YES CLASSES:  Target Counter({'yes': 9, 'no': 5})
INFO-GAIN FOR WIND IS : 0.04812703040826927
```

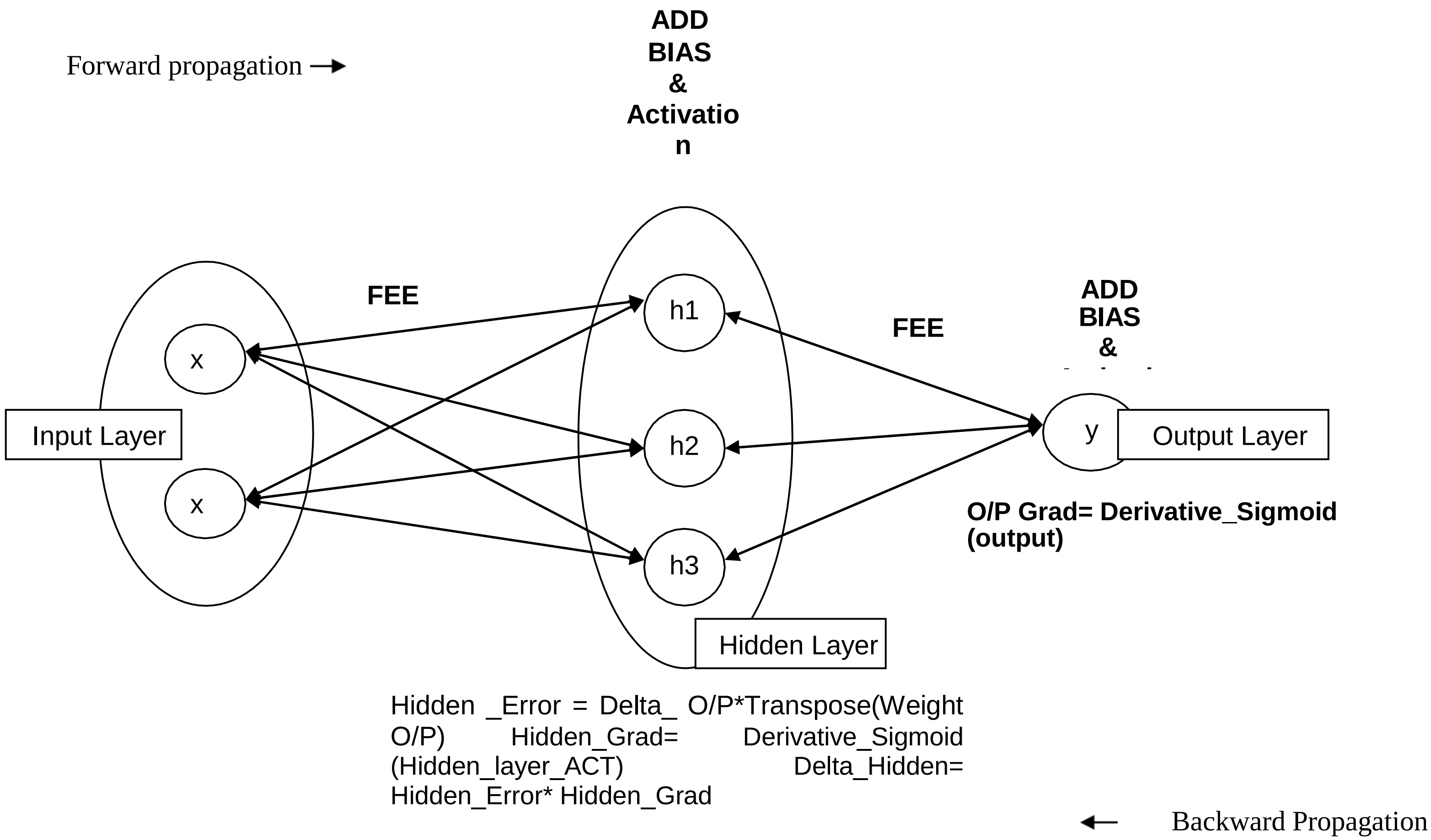
```
INFORMATION GAIN CALCULATION OF  Temperature
 hot
          Temperature Humidity    Wind Target
Outlook
sunny             hot     high    weak     no
sunny             hot     high  strong     no
overcast          hot     high    weak    yes
cool
          Temperature Humidity    Wind Target
Outlook
rain             cool   normal    weak    yes
rain             cool   normal  strong     no
overcast         cool   normal  strong    yes
sunny            cool   normal    weak    yes
hot
          Temperature Humidity  Wind Target
Outlook
overcast          hot   normal  weak    yes
mild
          Temperature Humidity    Wind Target
Outlook
rain             mild     high    weak    yes
sunny            mild     high    weak     no
rain             mild   normal    weak    yes
sunny            mild   normal  strong    yes
overcast         mild     high  strong    yes
rain             mild     high  strong     no
NO AND YES CLASSES:  Target Counter({'no': 2, 'yes': 1})
NO AND YES CLASSES:  Target Counter({'yes': 3, 'no': 1})
NO AND YES CLASSES:  Target Counter({'yes': 1})
NO AND YES CLASSES:  Target Counter({'yes': 4, 'no': 2})
NO AND YES CLASSES:  Target Counter({'yes': 9, 'no': 5})
INFO-GAIN FOR TEMPERATURE IS : 0.11815917264727838
```

5. Build an Artificial Neural Network by implementing the Back propagation algorithm and test the same using appropriate data sets.

Program:

```
import numpy as np
X = np.array(([2, 9], [1, 5], [3, 6]), dtype=float)
y = np.array(([92], [86], [89]), dtype=float)
X = X/np.amax(X,axis=0) # maximum of X array longitudinally
y = y/100
#Sigmoid Function
def sigmoid (x):
    return 1/(1 + np.exp(-x))
#Derivative of Sigmoid Function
def derivatives_sigmoid(x):
    return x * (1 - x)
#Variable initialization
epoch=1
 #Setting training iterations
lr=0.1 #Setting learning rate
inputlayer_neurons = 2 #number of features in data set
hiddenlayer_neurons = 3 #number of hidden layers neurons
output_neurons = 1 #number of neurons at output layer
#weight and bias initialization
wh=np.random.uniform(size=(inputlayer_neurons,hiddenlayer_neurons))
bh=np.random.uniform(size=(1,hiddenlayer_neurons))
wout=np.random.uniform(size=(hiddenlayer_neurons,output_neurons))
bout=np.random.uniform(size=(1,output_neurons))
#draws a random range of numbers uniformly of dim x*y
for i in range(epoch):
#Forward Propogation
    hinp1=np.dot(X,wh)
    hinp=hinp1 + bh
    hlayer_act = sigmoid(hinp)
    outinp1=np.dot(hlayer_act,wout)
    outinp= outinp1+ bout
    output = sigmoid(outinp)
#Backpropagation
    EO = y-output
    outgrad = derivatives_sigmoid(output)
    d_output = EO* outgrad
    EH = np.dot(d_output,wout.T)
    #wout.T is used to calculate the transpose of wout
    hiddengrad = derivatives_sigmoid(hlayer_act)
    #how much hidden layer wts contributed to error
    d_hiddenlayer = EH * hiddengrad
#Update weights and bias for next iteration
    wout += np.dot(hlayer_act.T,d_output) *lr
# dotproduct of nextlayererror and currentlayerop
    bout += np.sum(d_output, axis=0) *lr
    wh += X.T.dot(d_hiddenlayer) *lr
    bh += np.sum(d_hiddenlayer, axis=0) *lr
print("Input: \n" + str(X))
print("Actual Output: \n" + str(y))
print("Predicted Output: \n" ,output)
print("Final Error In Predicted Output: \n" ,str(y-output))
```

For this we consider:



The output is as follows:

```
Input:
[[0.66666667 1.        ]
 [0.33333333 0.55555556]
 [1.         0.66666667]]
Actual Output:
[[0.92]
 [0.86]
 [0.89]]
Predicted Output:
 [[0.88169538]
 [0.8710618 ]
 [0.88065579]]
Final Error In Predicted Output:
 [[ 0.03830462]
 [-0.0110618 ]
 [ 0.00934421]]
```

6. **Write a program to implement the naïve Bayesian classifier for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets.**

<u>The dataset to be considered is as follows :-</u>

Outlook	Temperat	Humidity	Wind	Target
sunny	hot	high	weak	no
sunny	hot	high	strong	no
overcast	hot	high	weak	yes
rain	mild	high	weak	yes
rain	cool	normal	weak	yes
rain	cool	normal	strong	no
overcast	cool	normal	strong	yes
sunny	mild	high	weak	no
sunny	cool	normal	weak	yes
rain	mild	normal	weak	yes
sunny	mild	normal	strong	yes
overcast	mild	high	strong	yes
overcast	hot	normal	weak	yes
rain	mild	high	strong	no

Program:

```
import numpy as np
import csv
def read_data(filename):
    with open(filename,'r') as csvfile:
        datareader = csv.reader(csvfile)
        metadata = next(datareader)
        traindata=[]
        for row in datareader:
            traindata.append(row)
        print(traindata,"\n")
        print("Metadata is:\n ",metadata)
    return (metadata, traindata)

def splitDataset(dataset, splitRatio):
    trainSize = int(len(dataset) * splitRatio)
    trainSet = []
    testset = list(dataset)
    i=0
    while len(trainSet) <trainSize:
        trainSet.append(testset.pop(i))
    return [trainSet, testset]
```

```python
def classify(train,test):
    train_rows = train.shape[0] #total training rows
    test_rows=test.shape[0]    #total testing rows
    train_col = train.shape[1]
    test_col = test.shape[1]
    print("training data size=",train_rows)
    print("test data size=",test.shape[0])
    countYes,countNo,probYes,probNo=0,0,0,0
    print("target    count    probability")
    for x in range(train_rows):
        if train[x,train_col-1] == 'yes':
            countYes +=1
        if train[x,train_col-1] == 'no':
            countNo +=1
    probYes=countYes/train_rows
    probNo= countNo / train_rows
    print('Yes',"\t",countYes,"\t",probYes)
    print('No',"\t",countNo,"\t",probNo)
    prob0 =np.zeros((test_col-1))
    prob1 =np.zeros((test_col-1))
    accuracy=0
    for t in range(test_rows):
        for k in range (test.shape[1]-1): #test.shape[1] refers to columns
            count1,count0=0,0
            for j in range (train_rows):
                if test[t,k] == train[j,k] and train[j,train_col-1]=='no':
                    count0+=1
                if test[t,k]==train[j,k] and train[j,train_col-1]=='yes':
                    count1+=1
            prob0[k]=count0/countNo
            prob1[k]=count1/countYes
    probno=probNo
    probyes=probYes
    for i in range(test_col-1):
        probno=probno*prob0[i]
        probyes=probyes*prob1[i]
        if probno>probyes:
            predict='no'
        else:
            predict='yes'
        if predict == test[t,test_col-1]:
            accuracy+=1
    final_accuracy=(accuracy/test_rows)*100
    print("accuracy",final_accuracy,"%")
    return
metadata,traindata= read_data("data3.csv")
splitRatio=0.8
trainingset, testset=splitDataset(traindata, splitRatio)
training=np.array(trainingset)
testing=np.array(testset)
print("Training :\n",training,"\nTesting: \n",testing)
classify(training,testing)
```

The output is as follows:

```
[['sunny', ' hot', ' high', 'weak', 'no'], ['sunny', ' hot', ' high', 'strong', 'no'],
['overcast', ' hot', ' high', 'weak', 'yes'], ['rain', 'mild', ' high', 'weak', 'yes'],
['rain', 'cool', 'normal', 'weak', 'yes'], ['rain', 'cool', 'normal', 'strong', 'no'],
['overcast', 'cool', 'normal', 'strong', 'yes'], ['sunny', 'mild', 'high', 'weak',
'no'], ['sunny', 'cool', 'normal', 'weak', 'yes'], ['rain', 'mild', 'normal', 'weak',
'yes'], ['sunny', 'mild', 'normal', 'strong', 'yes'], ['overcast', 'mild', 'high',
'strong', 'yes'], ['overcast', 'hot', 'normal', 'weak', 'yes'], ['rain', 'mild', 'high',
'strong', 'no']]

Metadata is:
  ['Outlook', 'Temperature', 'Humidity', 'Wind', 'Target']
```

```
Training :
 [['sunny' ' hot' ' high' 'weak' 'no']
 ['sunny' ' hot' ' high' 'strong' 'no']
 ['overcast' ' hot' ' high' 'weak' 'yes']
 ['rain' 'mild' ' high' 'weak' 'yes']
 ['rain' 'cool' 'normal' 'weak' 'yes']
 ['rain' 'cool' 'normal' 'strong' 'no']
 ['overcast' 'cool' 'normal' 'strong' 'yes']
 ['sunny' 'mild' 'high' 'weak' 'no']
 ['sunny' 'cool' 'normal' 'weak' 'yes']
 ['rain' 'mild' 'normal' 'weak' 'yes']
 ['sunny' 'mild' 'normal' 'strong' 'yes']]
Testing:
 [['overcast' 'mild' 'high' 'strong' 'yes']
 ['overcast' 'hot' 'normal' 'weak' 'yes']
 ['rain' 'mild' 'high' 'strong' 'no']]
training data size= 11
test data size= 3
target     count     probability
Yes        7         0.6363636363636364
No         4         0.36363636363636365
accuracy 66.66666666666666 %
```

7. **Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using *k*-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Java/Python ML library classes/API in the program.**

Program:

```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
from sklearn.cluster import KMeans
from sklearn.mixture import GaussianMixture
df1 = pd.read_csv("data8.csv")
print(df1)
f1 = df1['Distance_Feature'].values
f2 = df1['Speeding_Feature'].values
X = np.matrix(list(zip(f1,f2)))
plt.plot(1)
plt.subplot(511)
plt.xlim([0, 100])
plt.ylim([0, 50])
plt.title('Dataset')
plt.ylabel('speeding_feature')
plt.xlabel('distance_feature')
plt.scatter(f1,f2)
colors = ['b', 'g', 'r']
markers = ['o', 'v', 's']
# create new plot and data for K- means algorithm
plt.plot(2)
ax=plt.subplot(513)
kmeans_model = KMeans(n_clusters=3).fit(X)
for i, l in enumerate(kmeans_model.labels_):
    plt.plot(f1[i], f2[i], color=colors[l],marker=markers[l])
plt.xlim([0, 100])
plt.ylim([0, 50])
plt.title('K- Means')
plt.ylabel('speeding_feature')
plt.xlabel('distance_feature')
```

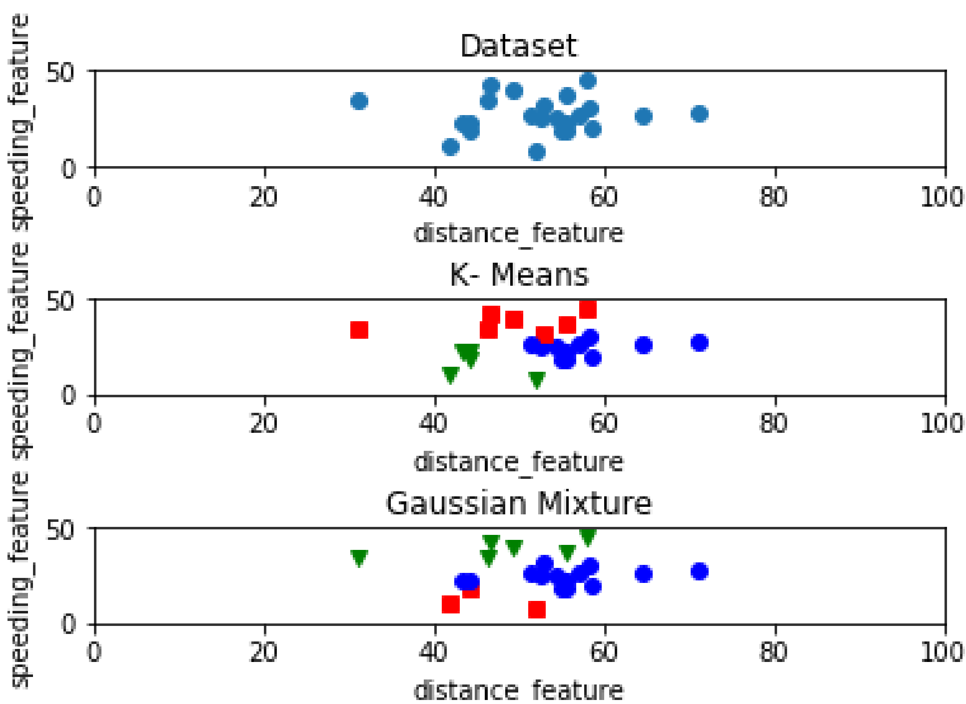
```python
# create new plot and data for gaussian mixture i.e. EM Algorithm
plt.plot(3)
plt.subplot(515)
gmm=GaussianMixture(n_components=3).fit(X)
labels= gmm.predict(X)
for i, l in enumerate(labels):
    plt.plot(f1[i], f2[i], color=colors[l], marker=markers[l])
plt.xlim([0, 100])
plt.ylim([0, 50])
plt.title('Gaussian Mixture')
plt.ylabel('speeding_feature')
plt.xlabel('distance_feature')
plt.show()
```

The dataset to be considered is:

1	Driver_ID	Distance_Feature	Speeding_Feature
2	3423311935	71.24	28
3	3423313212	52.53	25
4	3423313724	64.54	27
5	3423311373	55.69	22
6	3423310999	54.58	25
7	3423313857	41.91	10
8	3423312432	58.64	20
9	3423311434	52.02	8
10	3423311328	31.25	34
11	3423312488	44.31	19
12	3423311254	49.35	40
13	3423312943	58.07	45
14	3423312536	44.22	22
15	3423311542	55.73	19
16	3423312176	46.63	43
17	3423314176	52.97	32
18	3423314202	46.25	35
19	3423311346	51.55	27
20	3423310666	57.05	26
21	3423313527	58.45	30
22	3423312182	43.42	23
23	3423313590	55.68	37
24	3423312268	55.15	18

<u>The output is as follows:</u>

	Driver_ID	Distance_Feature	Speeding_Feature	Unnamed: 3
0	3423311935	71.24	28	NaN
1	3423313212	52.53	25	NaN
2	3423313724	64.54	27	NaN
3	3423311373	55.69	22	NaN
4	3423310999	54.58	25	NaN
5	3423313857	41.91	10	NaN
6	3423312432	58.64	20	NaN
7	3423311434	52.02	8	NaN
8	3423311328	31.25	34	NaN
9	3423312488	44.31	19	NaN
10	3423311254	49.35	40	NaN
11	3423312943	58.07	45	NaN
12	3423312536	44.22	22	NaN
13	3423311542	55.73	19	NaN
14	3423312176	46.63	43	NaN
15	3423314176	52.97	32	NaN
16	3423314202	46.25	35	NaN
17	3423311346	51.55	27	NaN
18	3423310666	57.05	26	NaN
19	3423313527	58.45	30	NaN
20	3423312182	43.42	23	NaN
21	3423313590	55.68	37	NaN
22	3423312268	55.15	18	NaN



8. **Write a program to implement *k*-Nearest Neighbor algorithm to classify the iris data set. Print both correct and wrong predictions. Java/Python ML library classes can be used for this problem.**

Program:

```
from sklearn import datasets
iris=datasets.load_iris()
iris_data=iris.data
iris_labels=iris.target
from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test=train_test_split(iris_data,iris_labels,test_size=0.30)

from sklearn.neighbors import KNeighborsClassifier
classifier=KNeighborsClassifier(n_neighbors=5)
classifier.fit(x_train,y_train)
y_pred=classifier.predict(x_test)

from sklearn.metrics import classification_report,confusion_matrix
print('Confusion matrix is as follows')
print(confusion_matrix(y_test,y_pred))
print('Accuracy Matrics')
print(classification_report(y_test,y_pred))
```

<u>The data set to be considered is:</u>

Iris Flower dataset from SKLearn is imported .

The output is as follows:

```
Confusion matrix is as follows
[[16  0  0]
 [ 0 19  3]
 [ 0  1  6]]
Accuracy Matrics
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        16
           1       0.95      0.86      0.90        22
           2       0.67      0.86      0.75         7

   micro avg       0.91      0.91      0.91        45
   macro avg       0.87      0.91      0.88        45
weighted avg       0.92      0.91      0.91        45
```

9. Implement the non-parametric Locally Weighted Regression algorithm in order to fit data points. Select appropriate data set for your experiment and draw graphs.

Program:

```python
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np1
def kernel(point, xmat, k):
    m,n=np1.shape(xmat)  #size of matrix m
    weights=np1.mat(np1.eye(m)) #np.eye returns mat with 1 in the diagonal
    for j in range(m):
        diff=point-xmat[j]
        weights[j,j]=np1.exp(diff*diff.T/(-2.0*k**2))
    return weights
def localWeight(point,xmat,ymat,k):
    wei=kernel(point,xmat,k)
    W=(xmat.T*(wei*xmat)).I*(xmat.T*(wei*ymat.T))
    return W
def localWeightRegression(xmat,ymat,k):
    row,col=np1.shape(xmat) #return 244 rows and  2 columns
    ypred=np1.zeros(row)
    for i in range(row):
        ypred[i]=xmat[i]*localWeight(xmat[i],xmat,ymat,k)
    return ypred
data=pd.read_csv('data10.csv')
bill=np1.array(data.total_bill)
tip=np1.array(data.tip)
mbill=np1.mat(bill)
mtip=np1.mat(tip)
mbillMatCol=np1.shape(mbill)[1] # 1 for vertical i.e columns
onesArray=np1.mat(np1.ones(mbillMatCol))
#hstack concate horizontal lists it takes one value from the fist and one from the second
xmat=np1.hstack((onesArray.T,mbill.T))
ypred=localWeightRegression(xmat,mtip,2)
SortIndex=xmat[ :,1].argsort(0)
#argsort take the index of each and sort them according to the orginal value
xsort=xmat[SortIndex][:,0]
fig= plt.figure()
ax=fig.add_subplot(1,1,1)
ax.scatter(bill,tip,color='blue')
ax.plot(xsort[:,1],ypred[SortIndex],color='red',linewidth=1)
plt.xlabel('Total bill')
plt.ylabel('tip')
plt.show();
```

The dataset considered is:

The overall dataset consists of over 200 hypothesis values. Out of this First 24 are given below:

1	total_bill	tip
2	16.99	1.01
3	10.34	1.66
4	21.01	3.5
5	23.68	3.31
6	24.59	3.61
7	25.29	4.71
8	8.77	2
9	26.88	3.12
10	15.04	1.96
11	14.78	3.23
12	10.27	1.71
13	35.26	5
14	15.42	1.57
15	18.43	3
16	14.83	3.02
17	21.58	3.92
18	10.33	1.67
19	16.29	3.71
20	16.97	3.5
21	20.65	3.35
22	17.92	4.08
23	20.29	2.75
24	15.77	2.23
25	39.42	7.58

The output is: