MP-1 PRACTICAL-10

1. Develop a python program to demonstrate the Transportation problem using Modi method (Initial solution can be of any method) in Linear Programming.

Code:

```
import numpy as np

def get_balanced_tp(supply, demand, costs, penalties = None):
    total_supply = sum(supply)
    total_demand = sum(demand)

    if total_supply < total_demand:
        if penalties is None:
            raise Exception('Supply less than demand, penalties required')
        new_supply = supply + [total_demand - total_supply]
        new_costs = costs + [penalties]
        return new_supply, demand, new_costs
    if total_supply > total_demand:
        new_demand = demand + [total_supply - total_demand]
        new_costs = costs + [[0 for _ in demand]]
        return supply, new_demand, new_costs
    return supply, demand, costs

def north_west_corner(supply, demand):
    supply_copy = supply.copy()
    demand_copy = demand.copy()
    i = 0
    j = 0
    bfs = []
    while len(bfs) < len(supply) + len(demand) - 1:
        s = supply_copy[i]
        d = demand_copy[j]
        v = min(s, d)
        supply_copy[i] -= v
        demand_copy[j] -= v
        bfs.append(((i, j), v))
        if supply_copy[i] == 0 and i < len(supply) - 1:
            i += 1
        elif demand_copy[j] == 0 and j < len(demand) - 1:
            j += 1
    return bfs

def get_us_and_vs(bfs, costs):
    us = [None] * len(costs)
    vs = [None] * len(costs[0])
    us[0] = 0
    bfs_copy = bfs.copy()
```

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while len(bfs_copy) > 0:
      for index, bv in enumerate(bfs_copy):
         i, j = bv[0]
         if us[i] is None and vs[j] is None: continue

         cost = costs[i][j]
         if us[i] is None:
            us[i] = cost - vs[j]
         else:
            vs[j] = cost - us[i]
         bfs_copy.pop(index)
         break

   return us, vs

def get_ws(bfs, costs, us, vs):
   ws = []
   for i, row in enumerate(costs):
      for j, cost in enumerate(row):
         non_basic = all([p[0] != i or p[1] != j for p, v in bfs])
         if non_basic:
            ws.append(((i, j), us[i] + vs[j] - cost))

   return ws

def can_be_improved(ws):
   for p, v in ws:
      if v > 0: return True
   return False

def get_entering_variable_position(ws):
   ws_copy = ws.copy()
   ws_copy.sort(key=lambda w: w[1])
   return ws_copy[-1][0]

def get_possible_next_nodes(loop, not_visited):
   last_node = loop[-1]
   nodes_in_row = [n for n in not_visited if n[0] == last_node[0]]
   nodes_in_column = [n for n in not_visited if n[1] == last_node[1]]
   if len(loop) < 2:
      return nodes_in_row + nodes_in_column
   else:
      prev_node = loop[-2]
      row_move = prev_node[0] == last_node[0]
      if row_move: return nodes_in_column
      return nodes_in_row

def get_loop(bv_positions, ev_position):
   def inner(loop):
      if len(loop) > 3:
            can_be_closed = len(get_possible_next_nodes(loop, [ev_position])) == 1
            if can_be_closed: return loop


        not_visited = list(set(bv_positions) - set(loop))
        possible_next_nodes = get_possible_next_nodes(loop, not_visited)
        for next_node in possible_next_nodes:
            new_loop = inner(loop + [next_node])
            if new_loop: return new_loop

    return inner([ev_position])

def loop_pivoting(bfs, loop):
    even_cells = loop[0::2]
    odd_cells = loop[1::2]
    get_bv = lambda pos: next(v for p, v in bfs if p == pos)
    leaving_position = sorted(odd_cells, key=get_bv)[0]
    leaving_value = get_bv(leaving_position)

    new_bfs = []
    for p, v in [bv for bv in bfs if bv[0] != leaving_position] + [(loop[0], 0)]:
        if p in even_cells:
            v += leaving_value
        elif p in odd_cells:
            v -= leaving_value
        new_bfs.append((p, v))

    return new_bfs


def modi_method(supply, demand, costs, penalties = None):
    balanced_supply, balanced_demand, balanced_costs = get_balanced_tp(
        supply, demand, costs
    )
    def inner(bfs):
        us, vs = get_us_and_vs(bfs, balanced_costs)
        ws = get_ws(bfs, balanced_costs, us, vs)
        if can_be_improved(ws):
            ev_position = get_entering_variable_position(ws)
            loop = get_loop([p for p, v in bfs], ev_position)
            return inner(loop_pivoting(bfs, loop))
        return bfs

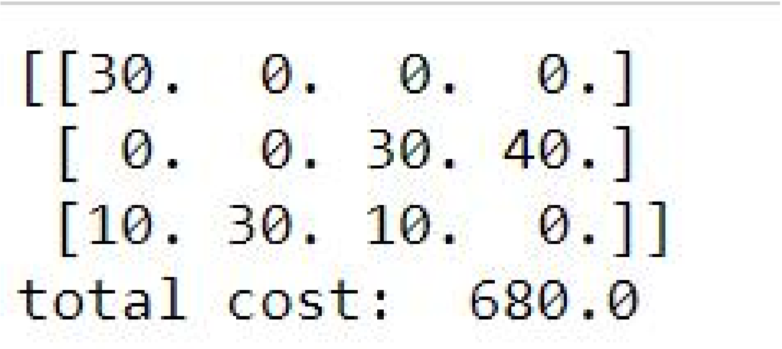
    basic_variables = inner(north_west_corner(balanced_supply, balanced_demand))
    solution = np.zeros((len(costs), len(costs[0])))
    for (i, j), v in basic_variables:
        solution[i][j] = v

    return solution
def get_total_cost(costs, solution):
    total_cost = 0
    for i, row in enumerate(costs):
        for j, cost in enumerate(row):
            total_cost += cost * solution[i][j]
    return total_cost




costs = [
    [ 2, 2, 2, 1],
    [10, 8, 5, 4],
    [ 7, 6, 6, 8]
]
supply = [30, 70, 50]
demand = [40, 30, 40, 40]
solution = modi_method(supply, demand, costs)
print(solution)
print('total cost: ', get_total_cost(costs, solution))
```

Output:-



```
[[30.  0.  0.  0.]
 [ 0.  0. 30. 40.]
 [10. 30. 10.  0.]]
total cost:  680.0
```