# hw6_report

December 11, 2022

# 1 MAS Final Homework Assignment

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[ ]:
```
# helper function for use in code code below
import random
import numpy as np

def set_seed(seed=42):
  rng = random.Random()
  if seed is None:
    seed = random.randint(0, 9999)
  rng.seed(seed)
  np.random.seed(seed)
```

## 1.1 1. Monte Carlo Estimation of Shapely Value

How to fairly split a taxi fare across $\{1, ...N\}$ players can be calculated using Shapely values, which treats this scenario as a cooperative game. For this problem we assume that all players live on the way of the Nth player, and that player $A$ lives at distance of 1, player $B$ at a distance of 2, etc.

### 1.1.1 Computing Shapely values for $n = 4$:

The code below computes all permutations (a.k.a. "coalitions") of the $N = 4$ players $\{A, B, C, D\}$, then for each permutation, `perm`, it assigns each player a share off the total payoff (the fare of total cost 4), by assuming player `perm[0]` showed up first at the taxi, followed by players `perm[1]`, `perm[2]`, `perm[3]`.

For example, for the permutation `perm = ['A', 'C', 'B', 'D']`, the respective payoffs (fare splits) will be `{'A': 1, 'B': 0, 'C': 2, 'D': 1}` (here player $B$ pays 0 because by the time player he arrives at the taxi, it was already going to go by the his house anyways due to player $C$.)

The final computed Shapely values are simply the average payoffs of each player across all possible permutations.

[ ]:
```
def get_perms(arr):
    """returns a list of the possible permutations of the entries in the␣
 ↪provided array."""
    all_perms = []
```

```python
    for p in arr:
        other_elems = sorted(list(set(arr) - set([p])))
        sub_perms = get_perms(other_elems)
        if len(sub_perms) == 0:
            all_perms.append([p])
        else:
            all_perms = all_perms + [[p] + perm for perm in sub_perms]
    return all_perms

def get_shapely(N):
    player_vals = {chr(ord('A') + n): n+1 for n in range(0, N)}
    #player_vals = {'A': 6, 'B': 12, 'C': 42} # should result in shapely values␣
 ↪{2, 5, 35}
    print("player_vals = ")
    print(player_vals)
    players = list(player_vals.keys())

    # list of permutations of coalitions of size len(players)
    perms = get_perms(players)
    print(f"there are {len(perms)} total permutations of {len(players)} players:
 ↪")
    display(perms[:5]) # print first few rows
    print('(only first 5 rows of permutations are shown above)')

    running_payoffs = {p: 0 for p in players}
    total_payoff = max(player_vals.values())
    for perm in perms:
        cur = {p: 0 for p in players}
        for p in perm: # compute share of payoff for each player in this␣
 ↪permutation
            cur[p] = max(0, player_vals[p] - sum(cur.values()))
        running_payoffs = {k: v+cur[k] for (k,v) in running_payoffs.items()}

    shapely_values = {k: v/len(perms) for (k,v) in running_payoffs.items()}
    print(f"\nshapely_values: (for N = {N})")
    print(shapely_values)

    #print('percent of payoff:')
    #print({k: v/total_payoff for (k,v) in shapely_values.items()})

get_shapely(4)
```

```
player_vals =
{'A': 1, 'B': 2, 'C': 3, 'D': 4}
there are 24 total permutations of 4 players:
```

```
[['A', 'B', 'C', 'D'],
 ['A', 'B', 'D', 'C'],
```

```
 ['A', 'C', 'B', 'D'],
 ['A', 'C', 'D', 'B'],
 ['A', 'D', 'B', 'C']]
```

```
(only first 5 rows of permutations are shown above)

shapely_values: (for N = 4)
{'A': 0.25, 'B': 0.5833333333333334, 'C': 1.0833333333333333, 'D':
2.0833333333333335}
```

As can be seen from the output, the shapely values for $n = 4$ players is `{'A': 0.25, 'B': 0.583, 'C': 1.083, 'D': 2.083}`

#### 1.1.2 Estimating Shapely values for $n = 100$

Here we use Monte Carlo sampling to approximiate the Shapely values for the taxi fare problem when $n = 100$.

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### 1.2 2. Monte Carlo Tree Search (MCTS)

[ ]:
```python
import math
import matplotlib.pyplot as plt
import networkx as nx
import numpy as np
import random
import importlib
import tree_search as ts
importlib.reload(ts)

#### experiment params
set_seed(None)
depth = 10
B = 25      # for computing values of leaf nodes
####

tree = ts.create_tree(depth)
#nx.draw(tree, with_labels=True, node_size=300)

first_leaf_node = tree.number_of_nodes() - 2**(depth-1) + 1
leaf_node_names = list(range(first_leaf_node, tree.number_of_nodes()+1))
#print(f"leaf nodes: {leaf_node_names}")

target_name = random.choice(leaf_node_names)
dists = [ts.edit_distance(tree.nodes[n]['address'], tree.
 ↪nodes[target_name]['address']) for n in leaf_node_names]
dmax = max(dists)
#print(f"dists: {dists}")
```

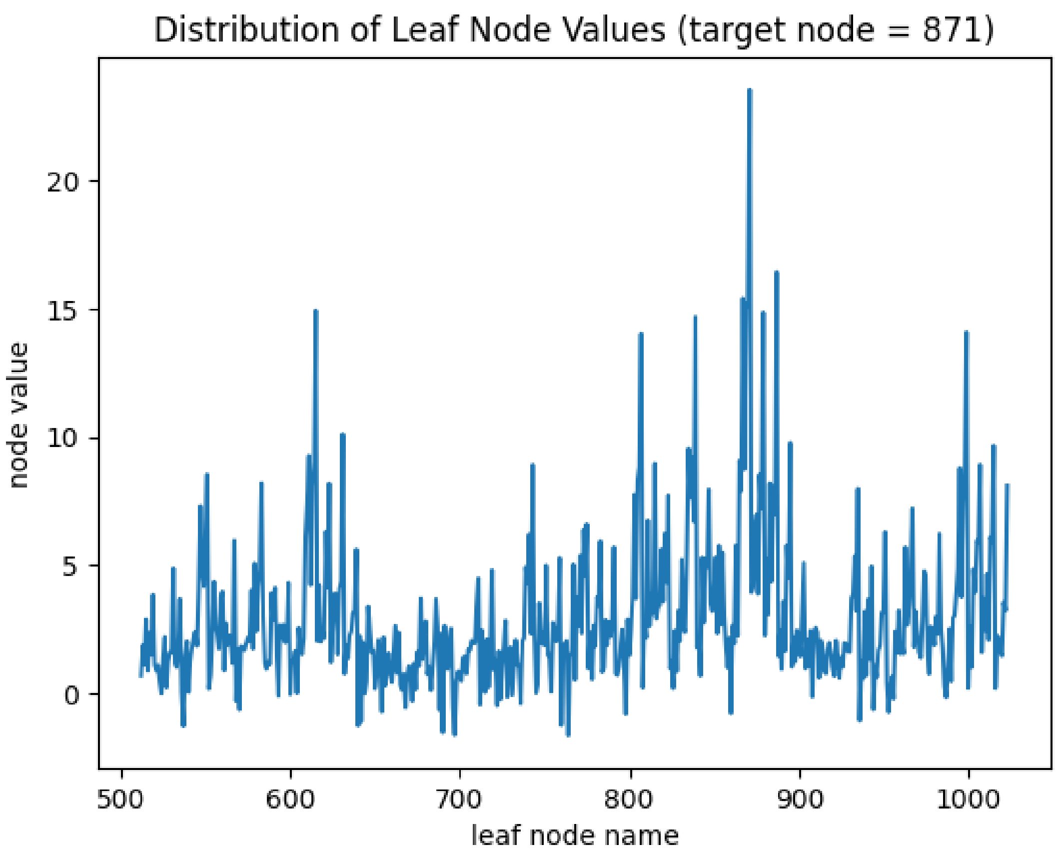
```python
print(f"target node = {target_name}, num leaf nodes = {len(leaf_node_names)},␣
↪max distance: {dmax}, min distance: {min(dists)}")
# compute values for each leaf node based on distance from target node
for idx, n in enumerate(leaf_node_names):
    tree.nodes[n]['value'] = B * math.pow(math.e, (-5 * dists[idx] / dmax)) +␣
↪np.random.normal()

leaf_vals = [tree.nodes[n]['value'] for n in leaf_node_names]
#print(f"vals: {leaf_vals}")

plt.xlabel('leaf node name')
plt.ylabel('node value')
plt.title(f'Distribution of Leaf Node Values (target node = {target_name})')
plt.plot(leaf_node_names, leaf_vals)
```

```
target node = 871, num leaf nodes = 512, max distance: 9, min distance: 0
```

[ ]: [<matplotlib.lines.Line2D at 0x7f2049c98220>]



### 1.3 RL: SARSA and Q-Learning

[ ]:
```python
import numpy as np

EMPTY = 0
WALL = 1
SNAKES = 2
TREASURE = 3

def create_world():
  world = np.zeros((9,9), dtype=int)
  world[1, 2:7] = WALL
  world[1:5, 6] = WALL
  world[7, 1:5] = WALL
  world[6:5] = SNAKES
  world[-1, -1] = TREASURE
  return world

world = create_world()
display(world)
```

```
array([[0, 0, 0, 0, 0, 0, 0, 0, 0],
       [0, 0, 1, 1, 1, 1, 1, 0, 0],
       [0, 0, 0, 0, 0, 0, 1, 0, 0],
       [0, 0, 0, 0, 0, 0, 1, 0, 0],
       [0, 0, 0, 0, 0, 0, 1, 0, 0],
       [0, 0, 0, 0, 0, 0, 0, 0, 0],
       [0, 0, 0, 0, 0, 0, 0, 0, 0],
       [0, 1, 1, 1, 1, 0, 0, 0, 0],
       [0, 0, 0, 0, 0, 0, 0, 0, 3]])
```

[ ]:
```python

```