

Test Cases Summary

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Initial State:

A	B	C	D	E	F	G	H	I	J
Country	Population	MetallicElements	Timber	MetallicAlloys	Electronics	Housing	HousingWaste	ElectronicsWaste	MetallicAlloysWaste
NewCaliforniaRepublic	80	50	50	40	80	20	20	20	20
NewReno	60	40	40	20	30	40	20	20	20
Arroyo	25	200	200	200	0	25	0	0	0
SanFrancisco	100	150	120	120	120	40	40	40	40
Gecko	40	20	10	20	10	20	80	80	80

Initial Resource Weights:

resource	weight
Population	0.5
MetallicElements	0.6
Timber	0.1
MetallicAlloys	0.4
Electronics	0.9
Housing	0.1
HousingWaste	-0.2
MetallicAlloysWaste	-0.2
ElectronicsWaste	-0.6

State Quality:

The state quality is measured by the amount of *Electronic* resources a country currently owns at a given time/state. Having the necessary raw materials to potentially produce Electronics is also weighed heavily, albeit at a discount. Finally, some electronics can be recycled (up to ~17%). So, not all E-Waste has a negative consequence.

Search Function:

The search function of choice is a Breadth-First Search, utilizing the *PriorityQueue* class from the Python library, *queue*. It generates children nodes based on a root or parent node. It then attempts to generate Action Templates to either TRANSFORM or TRANSFER. The resource values for the current node's country are modified by the Action. Next, the Expected Utility score on the current node is calculated and evaluated against the best scoring EU node. If so, replace the best EU node with the current node, and write all the Action Templates for all parent nodes of the current node. The program ends when the maximum depth or frontier size has been exceeded.

Test Case 1:

The goal of Test Case 1 is to stretch the limits of my program using a high max depth and frontier size. It also uses basic constant values utilized by the Expected Utility function.

```
# constant values for expected utility
GAMMA = 0.95
COST_OF_FAILURE = -0.10
L = 1
K = 1
X_0 = 0
```

```
parser.add_argument('--country-self', '-c', type=str, default="NewCaliforniaRepublic", help='init country to start')
parser.add_argument('--resource-file', '-r', type=str, default="src/input_files/world_resources_1.csv",
                    help='init resource csv filepath')
parser.add_argument('--state-file', '-s', type=str, default="src/input_files/world_state_1.csv",
                    help='init state country csv filepath')
parser.add_argument('--output-file', '-o', type=str, default="src/output_files/bfs_results",
                    help='output textfile filepath')
parser.add_argument('--num-schedules', '-ns', type=int, required=False, default=10,
                    help='expected num of output schedules to limit search space; not implemented yet')
parser.add_argument('--depth-bound', '-d', type=int, required=False, default=20,
                    help='expected max depth of tree to limit search space')
parser.add_argument('--frontier-size', '-f', type=int, required=False, default=15000,
                    help='expected max frontier size of queue to limit search space; not implemented')
parser.add_argument("--loglevel", "-l", action="store", default="INFO", help="logging level")
```

Test Case 1 Results:

```
=====
Schedule Num: 7
Node ID: 18896
Depth: 28
Expected Utility Score: 18.867680248072094
=====
[
  (TRANSFORM Housing NewCaliforniaRepublic
    (INPUTS (Population 5)
             (Metallic Elements 1)
             (Timber 5)
             (Metallic Alloys 3)
    )
    (OUTPUTS (Housing 1)
              (Housing Waste 1)
    )
  )
  (TRANSFER BETWEEN NewCaliforniaRepublic and NewReno
    (NewCaliforniaRepublic acquired MetallicAlloys 6
    NewReno acquired Timber 6)
  )
  (TRANSFER BETWEEN NewCaliforniaRepublic and NewReno
    (NewCaliforniaRepublic acquired MetallicElements 7
    NewReno acquired Timber 6)
  )
  (TRANSFER BETWEEN NewCaliforniaRepublic and NewReno
    (NewCaliforniaRepublic acquired Electronics 11
    NewReno acquired Timber 7)
  )
]
```

```
=====
Schedule Num: 9
Node ID: 5215
Depth: 28
Expected Utility Score: 19.811864182678166
=====
[
  (TRANSFORM Housing NewCaliforniaRepublic
    (INPUTS (Population 5)
             (Metallic Elements 1)
             (Timber 5)
             (Metallic Alloys 3)
    )
    (OUTPUTS (Housing 1)
              (Housing Waste 1)
    )
  )
  (TRANSFER BETWEEN NewCaliforniaRepublic and NewReno
    (NewCaliforniaRepublic acquired Electronics 11
    NewReno acquired Timber 12)
  )
  (TRANSFER BETWEEN NewCaliforniaRepublic and NewReno
    (NewCaliforniaRepublic acquired MetallicElements 11
    NewReno acquired Timber 7)
  )
  (TRANSFORM Housing NewReno
    (INPUTS (Population 5)
             (Metallic Elements 1)
             (Timber 5)
             (Metallic Alloys 3)
    )
    (OUTPUTS (Housing 1)
              (Housing Waste 1)
    )
  )
  (TRANSFER BETWEEN NewCaliforniaRepublic and NewReno
    (NewCaliforniaRepublic acquired MetallicAlloys 8
    NewReno acquired Timber 4)
  )
]
```

```
=====
Schedule Num: 9
Node ID: 175
Depth: 18
Expected Utility Score: 28.35705596368924
=====
[
  (TRANSFORM Housing NewCaliforniaRepublic
    (INPUTS (Population 5)
             (Metallic Elements 1)
             (Timber 5)
             (Metallic Alloys 3)
    )
    (OUTPUTS (Housing 1)
              (Housing Waste 1)
    )
  )
  (TRANSFER BETWEEN NewCaliforniaRepublic and NewReno
    (NewCaliforniaRepublic acquired MetallicElements 11
    NewReno acquired Timber 12)
  )
  (TRANSFER BETWEEN NewCaliforniaRepublic and NewReno
    (NewCaliforniaRepublic acquired MetallicAlloys 12
    NewReno acquired Timber 8)
  )
  (TRANSFER BETWEEN NewCaliforniaRepublic and SanFrancisco
    (NewCaliforniaRepublic acquired MetallicElements 16
    SanFrancisco acquired Electronics 10)
  )
  (TRANSFORM Housing NewReno
    (INPUTS (Population 5)
             (Metallic Elements 1)
             (Timber 5)
             (Metallic Alloys 3)
    )
    (OUTPUTS (Housing 1)
              (Housing Waste 1)
    )
  )
]
```

Files can be found on *src/output_files* directory, names include:

1. bfs_results_20depth_2023-03-26_23-56-56_test1a.txt
2. bfs_results_20depth_2023-03-26_23-57-18_test1b.txt
3. bfs_results_20depth_2023-03-26_23-59-25_test1c.txt
4. bfs_results_20depth_2023-03-27_01-24-25_test1d.txt
5. bfs_results_20depth_2023-03-27_01-24-39_test1e.txt

Test Case 1 Analysis:

Test Case 1 results yielded highly variable values for max depths reached and node counts. Depths levels reached ranged from 10 up to the max of 20. Node counts ranged from 100 to 10,000. There were generally more TRANSFER actions compared to TRANSFORM actions. The best EU scores hovered in the mid-teens.

Test Case 2:

The goal of Test Case 2 attempts to limit the parameters of the search algorithm by reducing the maximum depth bound to 10 or half of the setting in the previous test case. The max frontier size is also reduced from 15,000 to 500. Constant value changes include significantly increasing Cost of Failure (C) and halving the values for steepness of the curve (k) and sigmoid midpoint (x_o).

```
t('--num-schedules', '-ns', type=int, required=False, default=10,
    help='expected num of output schedules to limit search space; no
t('--depth-bound', '-d', type=int, required=False, default=10,
    help='expected max depth of tree to limit search space')
t('--frontier-size', '-f', type=int, required=False, default=500,
```

```
# Test Case 2
GAMMA = 0.95
COST_OF_FAILURE = -10
L = 1
K = 0.5
X_0 = 0.5
```

Test Case 2 Results:

```
=====
Schedule Num: 5
Node ID: 137
Depth: 7
Expected Utility Score: 132.2235264928072
=====
[
  (TRANSFORM Housing NewCaliforniaRepublic
    (INPUTS (Population 5)
             (Metallic Elements 1)
             (Timber 5)
             (Metallic Alloys 3)
            )
    (OUTPUTS (Housing 1)
              (Housing Waste 1)
            )
    )
  (TRANSFORM Housing NewCaliforniaRepublic
    (INPUTS (Population 5)
             (Metallic Elements 1)
             (Timber 5)
             (Metallic Alloys 3)
            )
    (OUTPUTS (Housing 1)
              (Housing Waste 1)
            )
    )
  (TRANSFER BETWEEN NewCaliforniaRepublic and NewReno
    (NewCaliforniaRepublic acquired Timber 6
     NewReno acquired MetallicAlloys 10)
    )
  (TRANSFORM Electronics NewCaliforniaRepublic
    (INPUTS (Population 1)
             (Metallic Elements 3)
             (Metallic Alloys 2)
            )
    (OUTPUTS (Electronics 2)
              (ElectronicsWaste 1)
            )
    )
]
```

```
=====
Schedule Num: 6
Node ID: 151
Depth: 6
Expected Utility Score: 131.99137848284442
=====
[
  (TRANSFORM Housing NewCaliforniaRepublic
    (INPUTS (Population 5)
             (Metallic Elements 1)
             (Timber 5)
             (Metallic Alloys 3)
            )
    (OUTPUTS (Housing 1)
              (Housing Waste 1)
            )
    )
  (TRANSFER BETWEEN NewCaliforniaRepublic and SanFrancisco
    (NewCaliforniaRepublic acquired MetallicAlloys 23
     SanFrancisco acquired Electronics 15)
    )
  (TRANSFER BETWEEN NewCaliforniaRepublic and NewReno
    (NewCaliforniaRepublic acquired MetallicAlloys 6
     NewReno acquired MetallicElements 7)
    )
  (TRANSFORM Housing NewCaliforniaRepublic
    (INPUTS (Population 5)
             (Metallic Elements 1)
             (Timber 5)
             (Metallic Alloys 3)
            )
    (OUTPUTS (Housing 1)
              (Housing Waste 1)
            )
    )
  (TRANSFORM Housing NewReno
    (INPUTS (Population 5)
             (Metallic Elements 1)
             (Timber 5)
             (Metallic Alloys 3)
            )
    (OUTPUTS (Housing 1)
              (Housing Waste 1)
            )
    )
]
```

```
=====
Schedule Num: 7
Node ID: 200
Depth: 8
Expected Utility Score: 132.22352649280708
=====
[
  (TRANSFORM Housing NewCaliforniaRepublic
    (INPUTS (Population 5)
             (Metallic Elements 1)
             (Timber 5)
             (Metallic Alloys 3)
            )
    (OUTPUTS (Housing 1)
              (Housing Waste 1)
            )
    )
  (TRANSFER BETWEEN NewCaliforniaRepublic and NewReno
    (NewCaliforniaRepublic acquired Timber 6
     NewReno acquired MetallicAlloys 11)
    )
  (TRANSFORM Housing NewCaliforniaRepublic
    (INPUTS (Population 5)
             (Metallic Elements 1)
             (Timber 5)
             (Metallic Alloys 3)
            )
    (OUTPUTS (Housing 1)
              (Housing Waste 1)
            )
    )
  (TRANSFORM Alloy NewCaliforniaRepublic
    (INPUTS (Population 1)
             (Metallic Elements 2)
            )
    (OUTPUTS (Metallic Alloys 1)
              (Metallic Alloys Waste 1)
            )
    )
  (TRANSFORM Alloy NewCaliforniaRepublic
    (INPUTS (Population 1)
             (Metallic Elements 2)
            )
    )
]
```

Files can be found on *src/output_files* directory, names include:

1. bfs_results_10depth_2023-03-27_00-15-25_test2a.txt
2. bfs_results_10depth_2023-03-27_00-15-42_test2b.txt
3. bfs_results_10depth_2023-03-27_00-16-31_test2c.txt
4. bfs_results_10depth_2023-03-27_01-23-22_test2d.txt
5. bfs_results_10depth_2023-03-27_01-23-34_test2e.txt

Test Case 2 Analysis:

Opposite of the first test, Test Case 2 results returned more consistent values across the board in terms of depth levels reached and node counts. Depth count ranges are above half (5-7) of the max setting of 10. Node count values were less than half (200) of the set frontier size (500). There were generally *less* TRANSFER actions compared to TRANSFORM actions. The best EU scores were consistently over 100.