

# simulation\_features\_minimum\_example

March 10, 2021

```
[1]: import math
import pandas as pd
import plotly
from numpy import random

pd.options.plotting.backend = "plotly"

from cadCAD.configuration.utils import config_sim

from cadCAD.engine import ExecutionMode, ExecutionContext
from cadCAD.engine import Executor

from cadCAD.configuration import Experiment

from cadCAD import configs
del configs[:] # Clear any prior configs

experiment = Experiment()

[2]: MONTE_CARLO_RUNS = 3

seeds = [random.RandomState(i) for i in range(MONTE_CARLO_RUNS)]

[3]: initial_state = {
    'population': 50, # number of sheep
    'food': 1000 # tons of grass
}

system_params = {
    'reproduction_rate': [0.3],
    'death_rate': [0.03],
    'consumption_rate': [0.03],
    'growth_rate': [30.0],
}

[4]: def s_population(params, substep, state_history, previous_state, policy_input):
    population = previous_state['population'] + policy_input['delta_population']
```

```

    return 'population', max(math.ceil(population), 0)

def s_food(params, substep, state_history, previous_state, policy_input):
    food = previous_state['food'] + policy_input['delta_food']
    return 'food', max(food, 0)

def p_reproduction(params, substep, state_history, previous_state):
    population_reproduction = params['reproduction_rate'] *
    ↪previous_state['food']
    return {'delta_population': population_reproduction}

def p_death(params, substep, state_history, previous_state):
    population_death = params['death_rate'] * previous_state['population']
    return {'delta_population': -population_death}

def p_growth(params, substep, state_history, previous_state):
    run = previous_state['run']
    food_growth = params['growth_rate'] * seeds[run - 1].rand()
    return {'delta_food': food_growth}

def p_consumption(params, substep, state_history, previous_state):
    food_consumption = params['consumption_rate'] * previous_state['population']
    return {'delta_food': -food_consumption}

```

```

[5]: partial_state_update_blocks = [
    {
        'policies': {
            'reproduction': p_reproduction,
            'death': p_death,
            'consumption': p_consumption,
            'growth': p_growth
        },
        'variables': {
            'population': s_population,
            'food': s_food
        }
    }
]

```

```

[6]: del configs[:]

SIMULATION_TIMESTEPS = 500

sim_config = config_sim({
    'N': MONTE_CARLO_RUNS,
    'T': range(SIMULATION_TIMESTEPS),
    'M': system_params
})

```

```

})

experiment.append_configs(
    initial_state = initial_state,
    partial_state_update_blocks = partial_state_update_blocks,
    sim_configs = sim_config,
)

```

```

[7]: exec_mode = ExecutionMode()
     exec_context = ExecutionContext()

     simulation = Executor(exec_context=exec_context, configs=configs)

```

```

[8]: raw_result, tensor_field, sessions = simulation.execute()
     df = pd.DataFrame(raw_result)
     sim_0 = df[df.simulation == 0]

```

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by cadCAD

```

```

Execution Mode: local_proc
Configuration Count: 1
Dimensions of the first simulation: (Timesteps, Params, Runs, Vars) = (500, 4,
3, 2)
Execution Method: local_simulations
SimIDs   : [0, 0, 0]
SubsetIDs: [0, 0, 0]
Ns       : [0, 1, 2]
ExpIDs   : [0, 0, 0]
Execution Mode: parallelized
Total execution time: 0.07s

```

```

[9]: simulation=0

```

```

[10]: seeds[simulation - 1].rand()

```

```

[10]: 0.26658984055727786

```

```

[11]: df[['simulation', 'subset', 'run', 'substep']].drop_duplicates()

```

```

[11]:
      simulation  subset  run  substep
0             0        0    1         0

```

1	0	0	1	1
501	0	0	2	0
502	0	0	2	1
1002	0	0	3	0
1003	0	0	3	1

```
[12]: import plotly.express as px

fig = px.line(df, x='timestep', y=['population', 'food'], facet_row='run',
             height=800, width=1000, title='Monte Carlo Runs')
fig.layout.font.size = 20
fig.show()
```

## 0.1 Parameter Sweeps

```
[13]: initial_state = {
        'population': 50, # number of sheep
        'food': 1000 # tons of grass
    }

system_params = {
    'reproduction_rate': [0.1, 0.2, 0.3],
    'death_rate': [0.01, 0.02, 0.03],
    'consumption_rate': [0.01, 0.02, 0.03],
    'growth_rate': [10, 20, 30.0],
}
```

```
[14]: def s_population(params, substep, state_history, previous_state, policy_input):
        population = previous_state['population'] + policy_input['delta_population']
        return 'population', max(math.ceil(population), 0)

    def s_food(params, substep, state_history, previous_state, policy_input):
        food = previous_state['food'] + policy_input['delta_food']
        return 'food', max(food, 0)

    def p_reproduction(params, substep, state_history, previous_state):
        population_reproduction = params['reproduction_rate'] *
        previous_state['food']
        return {'delta_population': population_reproduction}

    def p_death(params, substep, state_history, previous_state):
        population_death = params['death_rate'] * previous_state['population']
        return {'delta_population': -population_death}

    def p_growth(params, substep, state_history, previous_state):
        run = previous_state['run']
```

```

    food_growth = params['growth_rate']
    return {'delta_food': food_growth}

def p_consumption(params, substep, state_history, previous_state):
    food_consumption = params['consumption_rate'] * previous_state['population']
    return {'delta_food': -food_consumption}

```

```

[15]: partial_state_update_blocks = [
    {
        'policies': {
            'reproduction': p_reproduction,
            'death': p_death,
            'consumption': p_consumption,
            'growth': p_growth
        },
        'variables': {
            'population': s_population,
            'food': s_food
        }
    }
]

```

```

[16]: MONTE_CARLO_RUNS = 1

# del configs[:]

SIMULATION_TIMESTEPS = 500

sim_config = config_sim({
    'N': MONTE_CARLO_RUNS,
    'T': range(SIMULATION_TIMESTEPS),
    'M': system_params,
})

experiment.append_configs(
    initial_state = initial_state,
    partial_state_update_blocks = partial_state_update_blocks,
    sim_configs = sim_config,
)

```

```

[17]: exec_mode = ExecutionMode()
      exec_context = ExecutionContext()

      simulation = Executor(exec_context=exec_context, configs=configs)
      raw_result, tensor_field, sessions = simulation.execute()

```

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by cadCAD

```

```

Execution Mode: local_proc
Configuration Count: 2
Dimensions of the first simulation: (Timesteps, Params, Runs, Vars) = (500, 4,
3, 2)
Execution Method: local_simulations
SimIDs   : [0, 0, 0, 1, 1, 1]
SubsetIDs: [0, 0, 0, 0, 1, 2]
Ns        : [0, 1, 2, 0, 1, 2]
ExpIDs    : [0, 0, 0, 1, 1, 1]
Execution Mode: parallelized
Total execution time: 0.14s

```

```
[18]: df = pd.DataFrame(raw_result)
      df[['simulation', 'subset', 'run', 'substep']].drop_duplicates()
```

```
[18]:
```

	simulation	subset	run	substep
0	0	0	1	0
1	0	0	1	1
501	0	0	2	0
502	0	0	2	1
1002	0	0	3	0
1003	0	0	3	1
1503	1	0	1	0
1504	1	0	1	1
2004	1	1	2	0
2005	1	1	2	1
2505	1	2	3	0
2506	1	2	3	1

```
[19]: df = df[df.simulation == 1]
```

```
[20]: df
```

```
[20]:
```

	population	food	simulation	subset	run	substep	timestep
1503	50	1000.00	1	0	1	0	0
1504	150	1009.50	1	0	1	1	1
1505	250	1018.00	1	0	1	1	2
1506	350	1025.50	1	0	1	1	3
1507	450	1032.00	1	0	1	1	4
...	...	...	...	...	...	...	...

3001	1000	99.96	1	2	3	1	496
3002	1000	99.96	1	2	3	1	497
3003	1000	99.96	1	2	3	1	498
3004	1000	99.96	1	2	3	1	499
3005	1000	99.96	1	2	3	1	500

[1503 rows x 7 columns]

```
[21]: import plotly.express as px

fig = px.line(df, x='timestep', y=['population', 'food'], facet_row='subset',
             height=800, width=1000, title='Parameter Sweep Results')
fig.layout.font.size = 20
fig.show()
```

## 0.2 A|B Testing

```
[22]: import plotly.express as px

df = pd.DataFrame(raw_result)
fig = px.line(
    df,
    x='timestep',
    y=['population', 'food'],
    facet_row='run',
    facet_col='simulation',
    height=700,
    template='seaborn',
    title="A|B Testing"
)
fig.layout.font.size = 21

fig.update_layout(
    margin=dict(l=20, r=10, t=60, b=20),
)

fig.show()
```