

# execution\_time\_decorator

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## 1 Detailed execution time for cadCAD models

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This notebook shows how you can get detailed info about the execution time by using Python decorators on the minimal P&P model. The strategy is to make use of the decorator as defined in the next block, and use in the most convenient way.

There are two options: one is to make use of the decorator on the function definition, like by wrapping the `p_predator_births` and the `p_prey_births` policies.

The other option is to update the `partial_state_update_blocks` by a list comprehension, like `partial_state_update_blocks = [print_time(psub) for psub in partial_state_update_blocks]`. This is useful if you want to check everyone at once.

```
[1]: from time import time
import logging
from functools import wraps
logging.basicConfig(level=logging.DEBUG)

def print_time(f):
    """
    """
    @wraps(f)
    def wrapper(*args, **kwargs):
        # Current timestep
        t = len(args[2])
        t1 = time()
        f_out = f(*args, **kwargs)
        t2 = time()
        text = f"{t}|{f.__name__} output (exec time: {t2 - t1:.2f}s): {f_out}"
        logging.debug(text)
        return f_out
    return wrapper
```

## 1.1 Dependencies

```
[2]: %%capture
!pip install cadcad
```

```
[3]: import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
from cadCAD.configuration import Experiment
from cadCAD.configuration.utils import config_sim
from cadCAD.engine import ExecutionMode, ExecutionContext, Executor
```

```
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DEBUG:matplotlib:interactive is False
DEBUG:matplotlib:platform is linux
DEBUG:matplotlib:loaded modules: ['sys', 'builtins', '_frozen_importlib',
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'pandas.compat.chainmap', 'pandas.core.computation.scope',

```

'pandas.core.computation.ops', 'pandas.core.computation.engines',
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'pandas.io.excel._util', 'pandas.io.date_converters', 'pandas.io.parsers',
'pandas.io.excel._odfreader', 'pandas.io.excel._openpyxl',
'pandas.io.excel._pyxlsb', 'pandas.io.excel._xlrd', 'pandas.io.excel._base',
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'pandas._libs.testing', 'pandas._testing', 'pandas.testing', 'pandas._version',
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'matplotlib._animation_data', 'matplotlib.animation', 'pyparsing',
'matplotlib.fontconfig_pattern', 'matplotlib.docstring',
'matplotlib._color_data', 'matplotlib.colors', 'cycler', 'matplotlib.rcsetup',
'matplotlib._version', 'matplotlib.ft2font', 'kiwisolver']
DEBUG:matplotlib:CACHEDIR=/github/home/.cache/matplotlib
DEBUG:matplotlib.font_manager:Using fontManager instance from
/github/home/.cache/matplotlib/fontlist-v330.json
DEBUG:matplotlib.pyplot:Loaded backend module://ipykernel.pylab.backend_inline
version unknown.
DEBUG:matplotlib.pyplot:Loaded backend module://ipykernel.pylab.backend_inline
version unknown.

```

## 1.2 Definitions

### 1.2.1 Initial conditions and parameters

```

[4]: initial_conditions = {
    'prey_population': 100,
    'predator_population': 15
}

params = {
    "prey_birth_rate": [1.0],
    "predator_birth_rate": [0.01],
    "predator_death_const": [1.0],

```

```

    "prey_death_const": [0.03],
    "dt": [0.1] # Precision of the simulation. Lower is more accurate / slower
}

simulation_parameters = {
    'N': 1,
    'T': range(30),
    'M': params
}

```

### 1.2.2 Policies

```

[5]: @print_time
def p_predator_births(params, step, sL, s):
    dt = params['dt']
    predator_population = s['predator_population']
    prey_population = s['prey_population']
    birth_fraction = params['predator_birth_rate'] + np.random.random() * 0.0002
    births = birth_fraction * prey_population * predator_population * dt
    return {'add_to_predator_population': births}

@print_time
def p_pre_y_births(params, step, sL, s):
    dt = params['dt']
    population = s['prey_population']
    birth_fraction = params['prey_birth_rate'] + np.random.random() * 0.1
    births = birth_fraction * population * dt
    return {'add_to_pre_y_population': births}

def p_predator_deaths(params, step, sL, s):
    dt = params['dt']
    population = s['predator_population']
    death_rate = params['predator_death_const'] + np.random.random() * 0.005
    deaths = death_rate * population * dt
    return {'add_to_predator_population': -1.0 * deaths}

def p_pre_y_deaths(params, step, sL, s):
    dt = params['dt']
    death_rate = params['prey_death_const'] + np.random.random() * 0.1
    prey_population = s['prey_population']
    predator_population = s['predator_population']
    deaths = death_rate * prey_population * predator_population * dt
    return {'add_to_pre_y_population': -1.0 * deaths}

```

### 1.2.3 State update functions

```
[6]: def s_preyn_population(params, step, sL, s, _input):
    y = 'preyn_population'
    x = s['preyn_population'] + _input['add_to_preyn_population']
    return (y, x)

def s_predator_population(params, step, sL, s, _input):
    y = 'predator_population'
    x = s['predator_population'] + _input['add_to_predator_population']
    return (y, x)
```

### 1.2.4 State update blocks

```
[7]: partial_state_update_blocks = [
    {
        'policies': {
            'predator_births': p_predator_births,
            'preyn_births': p_preyn_births,
            'predator_deaths': p_predator_deaths,
            'preyn_deaths': p_preyn_deaths,
        },
        'variables': {
            'predator_population': s_preyn_population,
            'preyn_population': s_predator_population
        }
    }
]
```

### 1.2.5 Configuration and Execution

```
[8]: sim_config = config_sim(simulation_parameters)

exp = Experiment()
exp.append_configs(sim_configs=sim_config,
                  initial_state=initial_conditions,
                  partial_state_update_blocks=partial_state_update_blocks)

from cadCAD import configs
exec_mode = ExecutionMode()
exec_context = ExecutionContext(exec_mode.local_mode)
executor = Executor(exec_context=exec_context, configs=configs)
(records, tensor_field, _) = executor.execute()
```

DEBUG:root:1|p\_predator\_births output (exec time: 0.00s):

```

{'add_to_predator_population': 1.5279305558099918}
DEBUG:root:1|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
10.106543250226323}
DEBUG:root:2|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.5363878423803776}
DEBUG:root:2|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
10.119808758180069}
DEBUG:root:3|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.5375516607568764}
DEBUG:root:3|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
10.436957927361533}
DEBUG:root:4|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.4760229974330983}
DEBUG:root:4|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
9.848675314584217}
DEBUG:root:5|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.4909571503412207}
DEBUG:root:5|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
10.129588525199456}
DEBUG:root:6|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.4189441544388588}
DEBUG:root:6|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
9.753988975154089}
DEBUG:root:7|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.3817351991641056}
DEBUG:root:7|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
9.56839323770282}
DEBUG:root:8|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.3334606490580283}
DEBUG:root:8|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
9.367644741032178}
DEBUG:root:9|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.2606508531616378}
DEBUG:root:9|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
8.975753182791339}
DEBUG:root:10|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.2714042920474298}
DEBUG:root:10|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 9.320783088280299}
DEBUG:root:11|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.3193816382314143}
DEBUG:root:11|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 9.212798145799468}
DEBUG:root:12|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.2771751104909723}
DEBUG:root:12|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 9.728438374362307}
DEBUG:root:13|p_predator_births output (exec time: 0.00s):

```

```

{'add_to_predator_population': 1.2277088771123323}
DEBUG:root:13|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 9.056582301957702}
DEBUG:root:14|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.1434635989512751}
DEBUG:root:14|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 8.487803980499107}
DEBUG:root:15|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.1222218785685971}
DEBUG:root:15|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 8.830509102502617}
DEBUG:root:16|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.1158151053810252}
DEBUG:root:16|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 8.574005891445116}
DEBUG:root:17|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.1644293255554852}
DEBUG:root:17|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 8.985709693155753}
DEBUG:root:18|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.205516511513555}
DEBUG:root:18|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 9.625558827103234}
DEBUG:root:19|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.2204888392634388}
DEBUG:root:19|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 9.731394669836114}
DEBUG:root:20|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.1460497141994732}
DEBUG:root:20|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 9.316716805459007}
DEBUG:root:21|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.0736661338868418}
DEBUG:root:21|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 8.547194241088972}
DEBUG:root:22|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.0280226744228727}
DEBUG:root:22|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 8.19168064683684}
DEBUG:root:23|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 0.9591213037633962}
DEBUG:root:23|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 7.952538909261456}
DEBUG:root:24|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 0.8898366416545166}
DEBUG:root:24|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 7.740352058141636}
DEBUG:root:25|p_predator_births output (exec time: 0.00s):

```

```

{'add_to_predator_population': 0.8530844151828956}
DEBUG:root:25|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 7.73011725119693}
DEBUG:root:26|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 0.8488617715924541}
DEBUG:root:26|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 7.606519713065315}
DEBUG:root:27|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 0.8442444066933377}
DEBUG:root:27|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 7.575299128262298}
DEBUG:root:28|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 0.8268027568289155}
DEBUG:root:28|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 7.802504100984447}
DEBUG:root:29|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 0.8501694427626018}
DEBUG:root:29|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 8.432806014262015}
DEBUG:root:30|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 0.8195249201981478}
DEBUG:root:30|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 8.61147824447938}

```

```

      -----
  -----  --  -- / /  --- /  |  /  -- \
 /  --- /  --  /  -- / /  / / |  /  / / /
 /  / / /  / /  / /  / /  --- | /  / / /
 \  -- / \  ,  \  -- ,  \  --- / /  | /  --- /
by cadCAD

```

```

Execution Mode: local_proc
Configuration Count: 1
Dimensions of the first simulation: (Timesteps, Params, Runs, Vars) = (30, 5, 1,
2)
Execution Method: local_simulations
SimIDs      : [0]
SubsetIDs: [0]
Ns          : [0]
ExpIDs      : [0]
Execution Mode: single_threaded
Total execution time: 0.06s

```

### 1.2.6 Results

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

```
[10]: df = pd.DataFrame(records)

fig = px.line(df,
               x=df.prey_population,
               y=df.predator_population,
               color=df.run.astype(str))

fig.show()
```