

# 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 Dependences

```
[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
```

```
DEBUG:matplotlib:matplotlib data path: /github/home/.local/lib/python3.9/site-
packages/matplotlib/mpl-data
DEBUG:matplotlib:CONFIGDIR=/github/home/.config/matplotlib
DEBUG:matplotlib:matplotlib version 3.4.0
DEBUG:matplotlib:interactive is False
DEBUG:matplotlib:platform is linux
DEBUG:matplotlib:loaded modules: ['sys', 'builtins', '_frozen_importlib',
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 'pandas.core.util.hashing', 'pandas.util', 'pandas.util.\_validators',  
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 'pandas.core.indexers', 'pandas.core.algorithms',  
 'pandas.compat.numpy.function', 'pandas.\_libs.ops', 'pandas.core.ops.roperator',  
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 'pandas.core.ops.common', 'pandas.core.ops.docstrings',  
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 'pandas.core.arrays.base', 'pandas.core.nanops', 'pandas.core.array\_algos',  
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'pandas.tseries.frequencies', 'pandas.core.arrays.datetimelike',  
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 'pandas.core.aggregation', 'pandas.\_libs.indexing', 'pandas.core.indexing',  
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 'pandas.core.internals.concat', 'pandas.core.internals',  
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 'pandas.core.window.indexers', 'pandas.core.window.numba\_',  
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 'pandas.compat.chainmap', 'pandas.core.computation.scope',  
 'pandas.core.computation.ops', 'pandas.core.computation.engines',  
 'pandas.core.computation.parsing', 'pandas.core.computation.expr',

```

'pandas.core.computation.eval', 'pandas.core.computation.api',
'pandas.core.reshape.merge', 'pandas.core.reshape.pivot',
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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',
'pandas._libs.json', 'pandas.io.formats._color_data', 'pandas.io.formats.css',
'pandas.io.formats.excel', 'pandas.io.excel._odswriter',
'pandas.io.excel._xlsxwriter', 'pandas.io.excel._xlwt', 'pandas.io.excel',
'pandas.io.feather_format', 'pandas.io.gbq', 'pandas.io.html',
'pandas.io.json._normalize', 'pandas.io.json._table_schema',
'pandas.io.json._json', 'pandas.io.json', 'pandas.io.orc', 'pandas.io.parquet',
'pandas.compat.pickle_compat', 'pandas.io.pickle',
'pandas.core.computation.pytables', 'pandas.io.pytables',
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'pandas.io.stata', 'pandas.io.api', 'pandas.util._tester', 'cmath',
'pandas._libs.testing', 'pandas._testing', 'pandas.testing', 'pandas._version',
'pandas', 'matplotlib', 'matplotlib._api.deprecation', 'matplotlib._api',
'matplotlib._c_internal_utils', 'matplotlib.cbook', 'matplotlib.docstring',
'PIL._version', 'PIL', 'xml.etree', 'xml.etree.ElementPath', 'pyexpat.errors',
'pyexpat.model', 'pyexpat', '_elementtree', 'xml.etree.ElementTree',
'PIL.ImageMode', 'PIL.TiffTags', 'PIL._binary', 'PIL._util', 'PIL._imaging',
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'PIL.PngImagePlugin', 'matplotlib._path', 'matplotlib.bezier',
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'matplotlib.scale', 'matplotlib._color_data', 'matplotlib.colors', 'pyparsing',
'matplotlib.fontconfig_pattern', 'matplotlib._enums', 'cyclor',
'matplotlib.rcsetup', 'matplotlib._version', 'matplotlib.ft2font', 'kiwisolver',
'dateutil.rrule', 'matplotlib.units', 'matplotlib.dates']
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_predeaths(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_predeaths': -1.0 * deaths}

```

### 1.2.3 State update functions

```

[6]: def s_predeaths(params, step, sL, s, _input):
    y = 'predeaths'
    x = s['predeaths'] + _input['add_to_predeaths']
    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,
            'prey_births': p_predeaths,
            'predator_deaths': p_predator_deaths,
            'prey_deaths': p_predeaths,
        },
        'variables': {
            'predator_population': s_predator_population,
            'prey_population': s_predeaths
        }
    }
]

```

### 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': 1.520768590990804}
DEBUG:root:1|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
10.743044075752039}
DEBUG:root:2|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.5938402879419904}
DEBUG:root:2|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
10.919348895662116}
DEBUG:root:3|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.5047568321363012}
DEBUG:root:3|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
10.163527042254652}
DEBUG:root:4|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.5214273692089109}
DEBUG:root:4|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
10.77961804351155}
DEBUG:root:5|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.432513993680724}
DEBUG:root:5|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
9.550022321679732}
DEBUG:root:6|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.4355353882988153}
DEBUG:root:6|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
10.474316339006608}
DEBUG:root:7|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.3979528515198016}
DEBUG:root:7|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
10.185189012384702}
DEBUG:root:8|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.2957303133388889}
DEBUG:root:8|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
9.356429383041666}
```

```

DEBUG:root:9|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.2793165975921477}
DEBUG:root:9|p_pre_y_births output (exec time: 0.00s): {'add_to_pre_y_population':
9.17871703887519}
DEBUG:root:10|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.341706297992561}
DEBUG:root:10|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 9.921304909930065}
DEBUG:root:11|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.2312629547548113}
DEBUG:root:11|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 8.758323255311154}
DEBUG:root:12|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.218388606297686}
DEBUG:root:12|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 8.969180680911775}
DEBUG:root:13|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.2431716418664154}
DEBUG:root:13|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 8.847585327772354}
DEBUG:root:14|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.156658641846941}
DEBUG:root:14|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 8.398726775576021}
DEBUG:root:15|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.1337528627844333}
DEBUG:root:15|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 8.862486195078965}
DEBUG:root:16|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.1745808096035135}
DEBUG:root:16|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 9.1419924496688}
DEBUG:root:17|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.2300428437929916}
DEBUG:root:17|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 9.291705628594825}
DEBUG:root:18|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.2024269769889093}
DEBUG:root:18|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 9.983558099664819}
DEBUG:root:19|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.2482737053478459}
DEBUG:root:19|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 10.28905093176423}
DEBUG:root:20|p_predator_births output (exec time: 0.00s):
{'add_to_predator_population': 1.3277927053329075}
DEBUG:root:20|p_pre_y_births output (exec time: 0.00s):
{'add_to_pre_y_population': 10.778366307537034}

```

15

```
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: 0.08s
```

### 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()
```