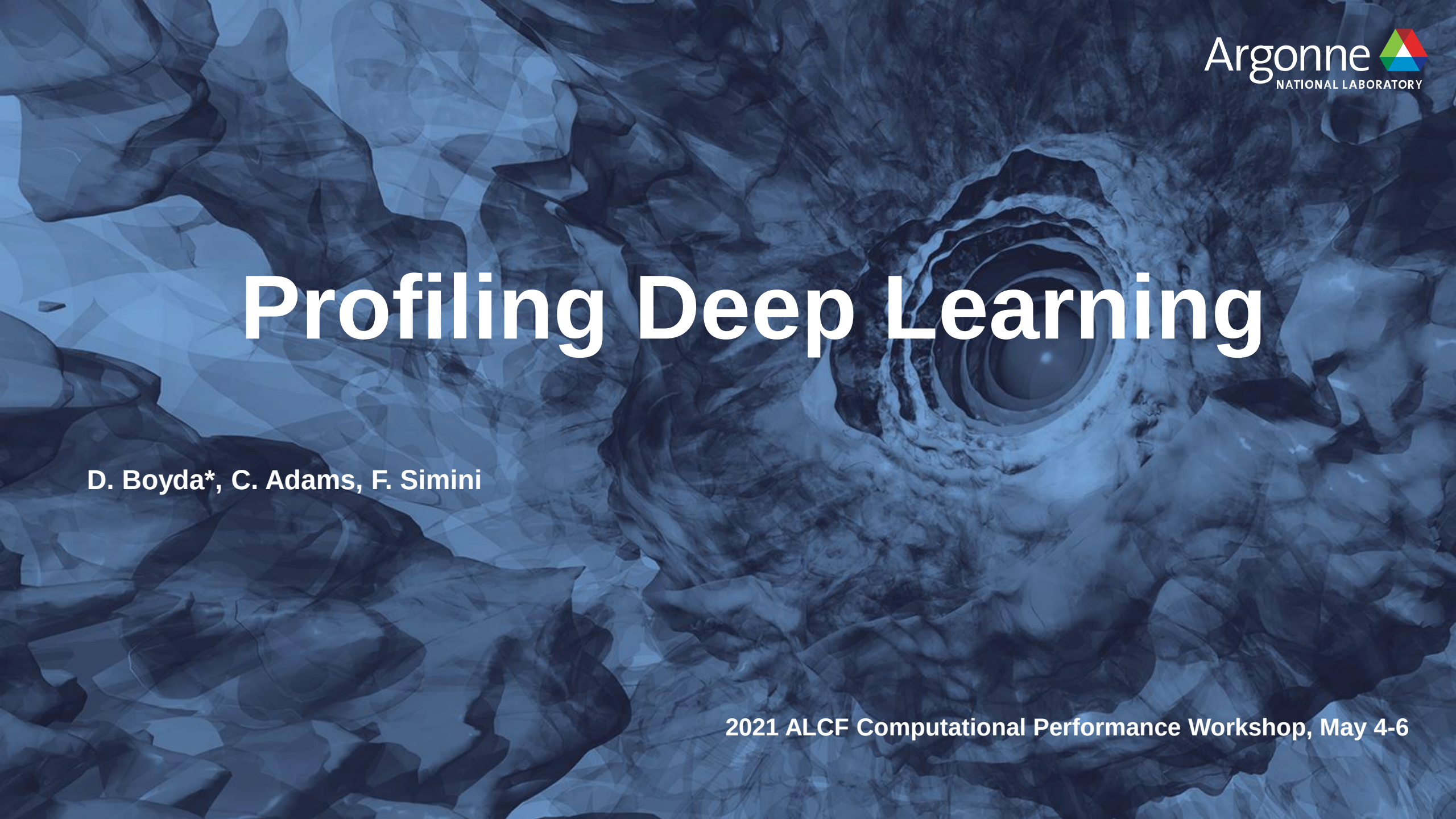

Profiling Deep Learning

D. Boyda*, C. Adams, F. Simini

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Outline

- What is profiling
- Motivation to profile
- Some frequent problems
- Common Profiler APIs
- Understanding profiler output
- New PyTorch Profiler view

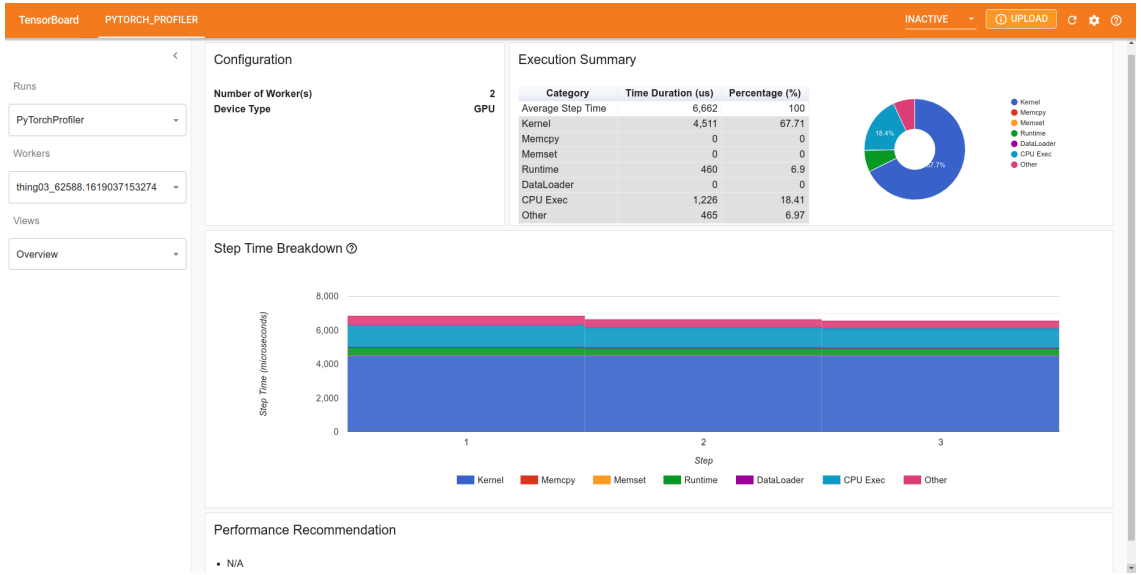
What is profiling?

- Measuring time/memory cost
- Identifying bottleneck
- Tracking call stack

```
         181 function calls (169 primitive calls) in 3.434 seconds

   Ordered by: cumulative time

   ncalls  tottime  percall  cumtime  percall filename:lineno(function)
     10/1    0.000    0.000    3.434    3.434 module.py:866(_call_impl)
        1    0.078    0.078    3.434    3.434 v2.py:21(forward)
        1    0.000    0.000    2.817    2.817 <__array_function__ internals>:2(argwhere)
      4/1    0.000    0.000    2.817    2.817 {built-in method numpy.core._multiarray_umath.implement_array_function}
        1    0.005    0.005    2.817    2.817 numeric.py:537(argwhere)
        2    0.000    0.000    2.812    1.406 fromnumeric.py:52(_wrapfunc)
        1    0.000    0.000    1.476    1.476 <__array_function__ internals>:2(nonzero)
        1    0.000    0.000    1.476    1.476 fromnumeric.py:1816(nonzero)
        1    1.476    1.476    1.476    1.476 {method 'nonzero' of 'numpy.ndarray' objects}
        1    0.000    0.000    1.335    1.335 <__array_function__ internals>:2(transpose)
        1    0.000    0.000    1.335    1.335 fromnumeric.py:601(transpose)
        1    0.000    0.000    1.335    1.335 fromnumeric.py:39(_wrapit)
        1    0.000    0.000    1.335    1.335 _asarray.py:14(asarray)
        1    1.335    1.335    1.335    1.335 {built-in method numpy.array}
        1    0.348    0.348    0.348    0.348 {method 'cuda' of 'torch._C._TensorBase' objects}
        1    0.188    0.188    0.188    0.188 {method 'cpu' of 'torch._C._TensorBase' objects}
        1    0.003    0.003    0.003    0.003 {method 'item' of 'torch._C._TensorBase' objects}
```



Motivation to profile

What is the purpose of profiling?

- finding performance issues
- optimizations and tuning
- fine-tuning

Do you need to deeply profile/optimize your script?

- training vs evaluation
- Are you developing your model or you already know the solution?
- Is your accuracy increasing with scaling?

- Is speed up worth your affords?
  - Is GPU utilization high?
  - Do you expect high improvements?
  - Are you planning to scale?

“Premature optimization is the root of all evil!”
@Donald Knuth

Some frequent problems

- slow IO
  - Use designated PT/TF data loaders
  - Multithreading
- (extra) copy CPU ↔ GPU
  - Move all operations to device
    - Rewrite your code with using only PT/TF tensors
    - Use Numba / CuPy
  - Overlap copy and computation
  - Use asynchronous copy
- small batch size
  - Increase batch size until you totally load GPU
- high precision
  - Can you decrease precision to float/half?
  - Autotuning mixed precision in PT

Common profiler APIs

- Context manager

```
with profiler.profile() as prof:
    model(inputs)
```

```
with torch.profiler.profile(
        activities=[torch.profiler.ProfilerActivity.CPU,
                    torch.profiler.ProfilerActivity.CUDA],
        schedule=torch.profiler.schedule(wait=0, warmup=1, active=3),
        on_trace_ready=torch.profiler.tensorboard_trace_handler(dir_name)
        ) as prof:

    for _ in range(8):
        model(inputs)
```

- Decorator

```
@profile
def train_loop(batch_size, n_training_iterations, models, opts, global_size):

    logger = logging.getLogger()

    rank = hvd.rank()
    for i in range(n_training_iterations):
```

- Python module

```
python -m line_profiler train_GAN.py.lprof
```

```
python -m torch.utils.bottleneck example2/v3.py
```

Understanding profiler output

no subfunction calls included

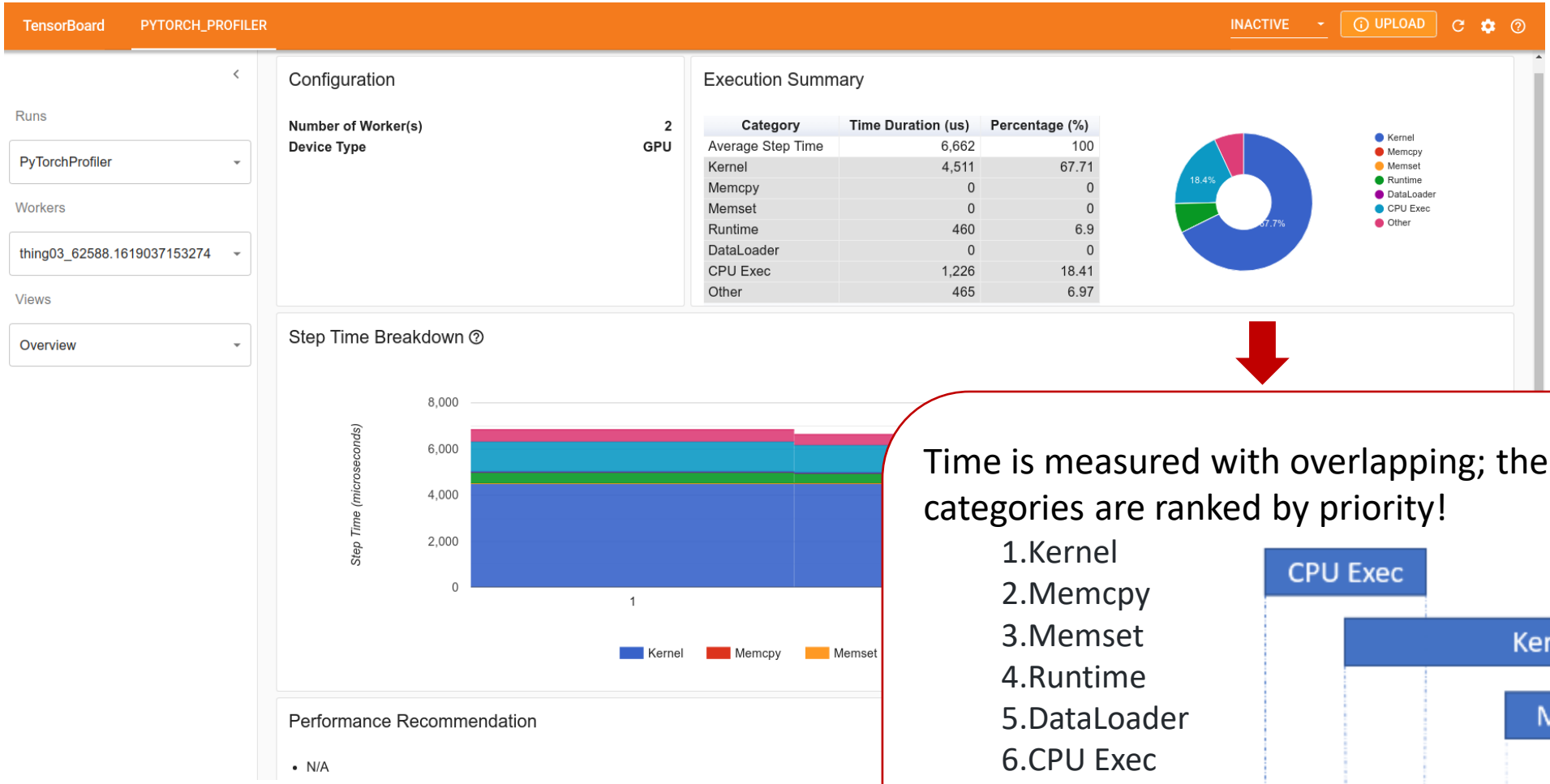
time including all subroutines calls

Name	Self CPU %	Self CPU	CPU total %	CPU total	CPU time avg	# of Calls
aten::nonzero	96.00%	15.948ms	96.08%	15.962ms	15.962ms	1
LABEL1: linear pass	0.82%	136.417us	2.67%	442.910us	442.910us	1
aten::addmm	0.78%	130.082us	0.93%	153.704us	38.426us	4
LABEL2: masking	0.34%	56.329us	96.98%	16.112ms	16.112ms	1
aten::threshold	0.26%	43.308us	0.33%	54.649us	13.662us	4

Self CPU time total: 16.613ms

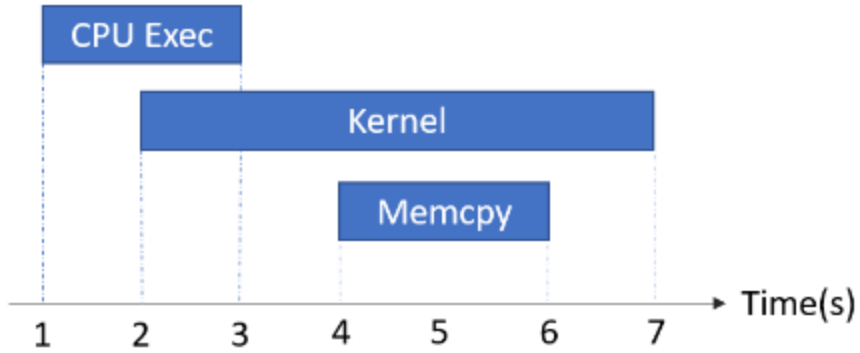
- additional metrics can be shown
- line in source files can be added
- one can sort by different metrics

New PyTorch Profiler view



Time is measured with overlapping; the categories are ranked by priority!

1. Kernel
2. Memcpy
3. Memset
4. Runtime
5. DataLoader
6. CPU Exec
7. Other

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Let’s play with examples!