PROFILING WITH POPVISION

June 12, 2024

Alexander Tsyplikhin

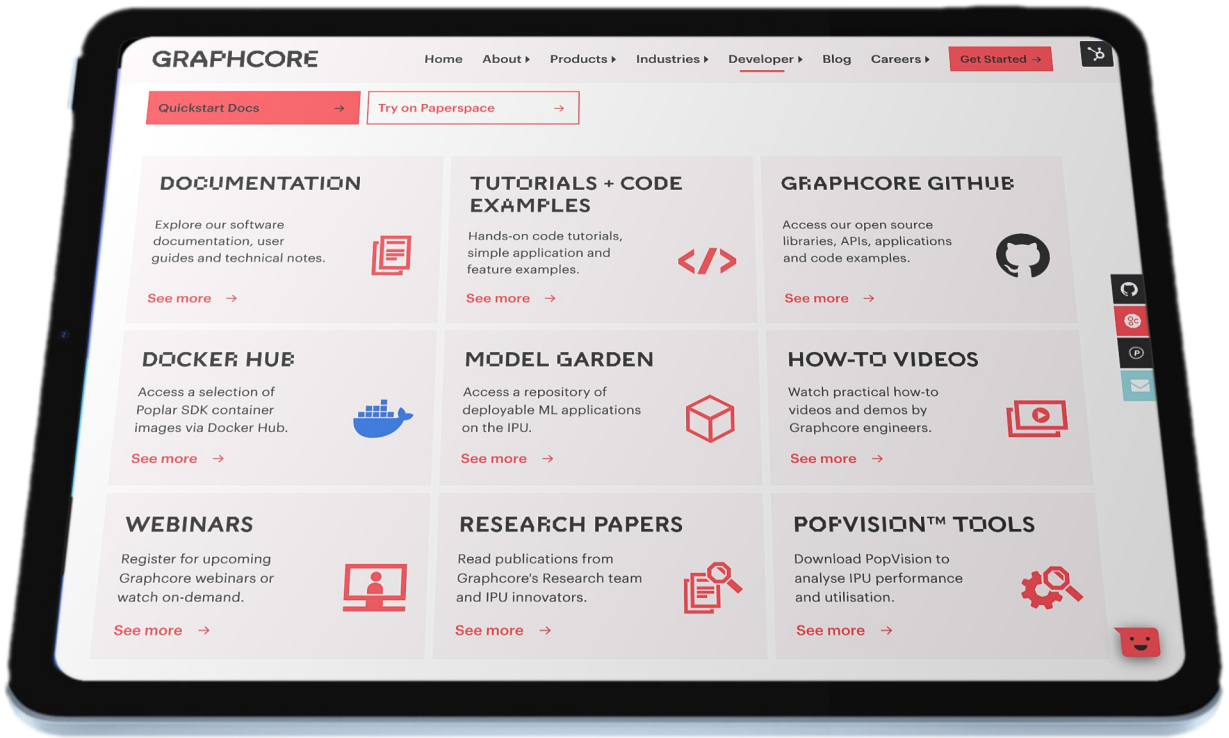
GRAPHCORE

AGENDA

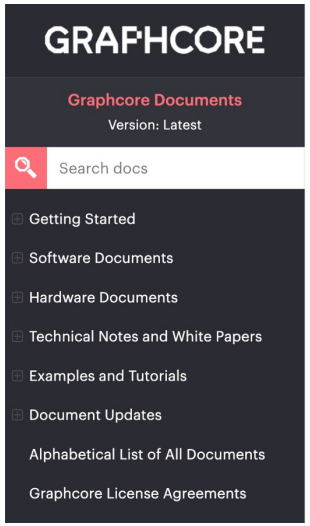
- PopVision Tools
  - PopVision Graph Analyser
  - PopVision System Analyser

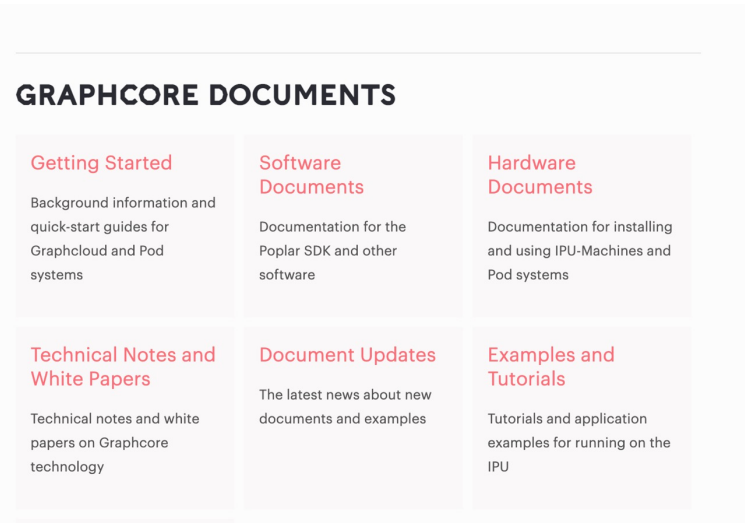
GRAPHCORE SOFTWARE ECOSYSTEM

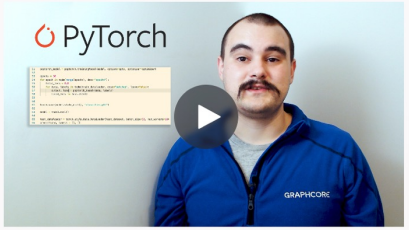
WORLD CLASS DEVELOPER RESOURCES FOR IPU USERS



WWW.GRAPHCORE.AI/DEVELOPER







Getting started with PyTorch for the IPU

Running a basic model for training and inference

AI Customer Engineer, Chris Bogdiukiewicz introduces PyTorch for the IPU. With PopTorch™ - a simple Python wrapper for PyTorch programs, developers can easily run models, directly on Graphcore IPUs with a few lines of extra code.

In this video, Chris provides a quick demo on running a basic model for both training and inference using a MNIST based example.

Get the Code →

Read the Guide →

GRAPHCORE SOFTWARE

NLP/TRANSFORMERS
IMAGE CLASSIFICATION/CNNS
OBJECT DETECTION
LARGE MODELS
MLPERF
CONDITIONAL SPARSITY
GNNS

ML APPLICATIONS

TUTORIALS
CODE EXAMPLES
DOCUMENTATION
VIDEOS
NATIVE IPU CODERS PROGRAM
APPS PORTFOLIO

DEVELOPER ECOSYSTEM

FRONTENDS
JUPYTER NOTEBOOKS
INFERENCE DEPLOYMENT TOOLKIT

FRAMEWORKS
ONNX
HALO
Keras
PaddlePaddle

FW BACKENDS
XLA
POPART+
POPDIST

POPLAR®
PARTITIONER
POPIR
POPIT
POPLIBS
GCL
POPLAR
GRAPH ENGINE
GRAPH COMPILER

DRIVERS
GC DEVICE ACCESS LAYER
IPUOF DRIVER
PCIe DRIVER

POPLAR® SDK

GRAPH ANALYZER
SYSTEM ANALYZER
DEBUGGER
DEVELOPMENT ENVIRONMENT

POPVISION TOOLS

V-IPU

SYSTEM MONITORING
PROMETHEUS
GRAFANA

JOB DEPLOYMENT
K8S
SLURM

SYSTEM SOFTWARE

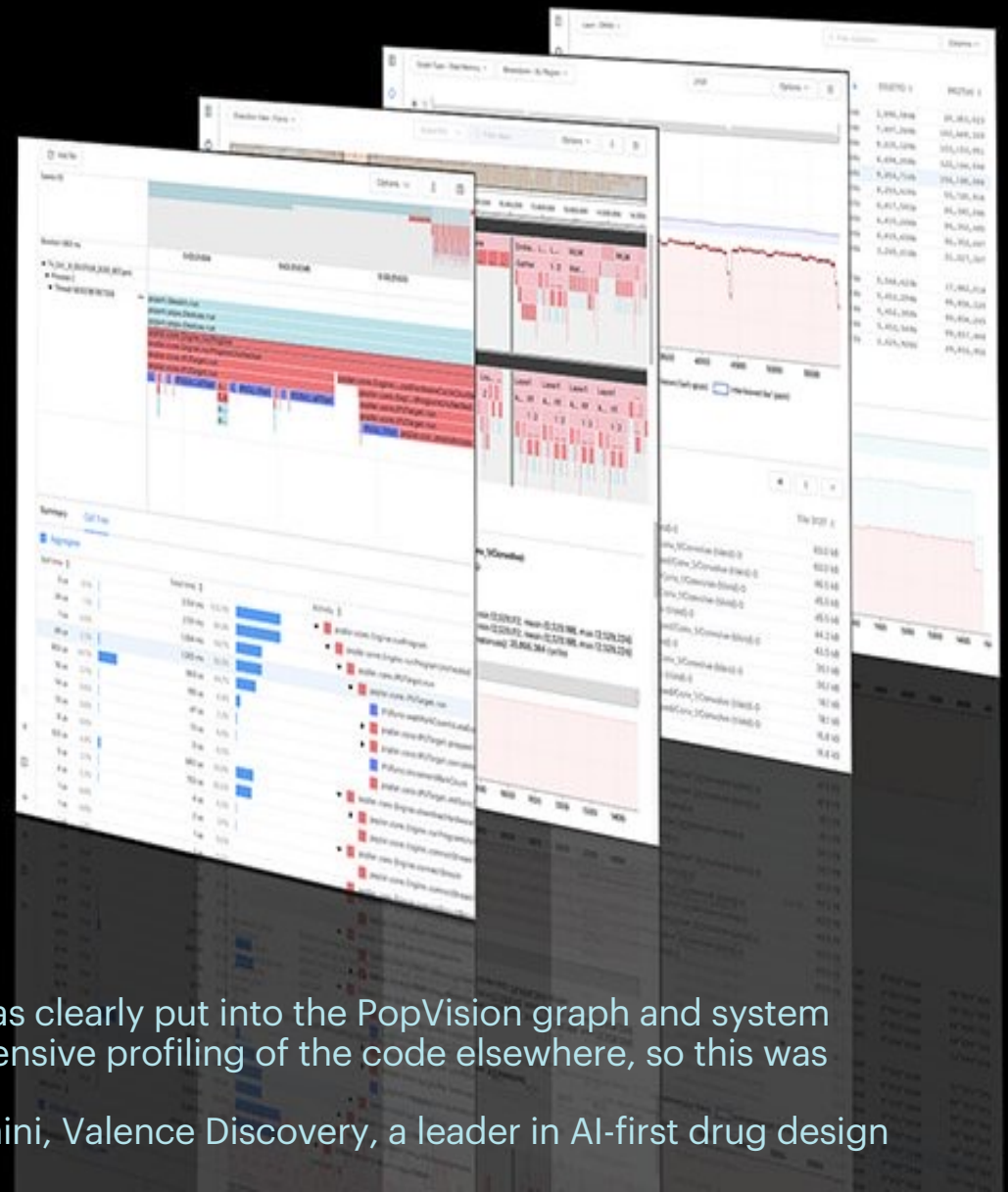
POPVISION™ TOOLS

GRAPH ANALYSER

Useful for analysing and optimising the memory use and execution performance of ML models on the IPU

SYSTEM ANALYSER

Graphical view of the timeline of host-side application execution steps

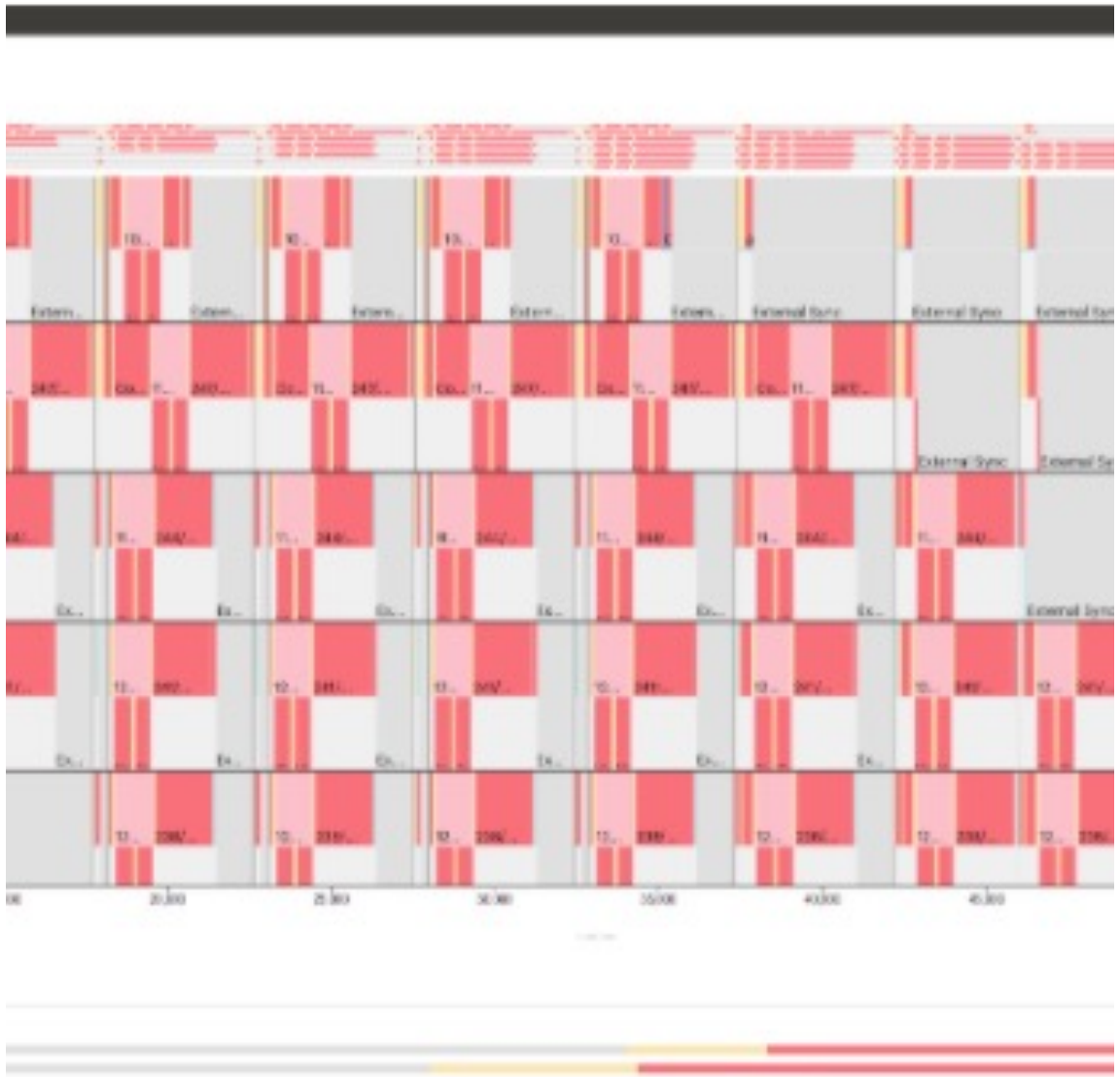


"Our team was very impressed by the care and effort Graphcore has clearly put into the PopVision graph and system analysers. It's hard to imagine getting such a helpful and comprehensive profiling of the code elsewhere, so this was really a standout feature in our IPU experience."

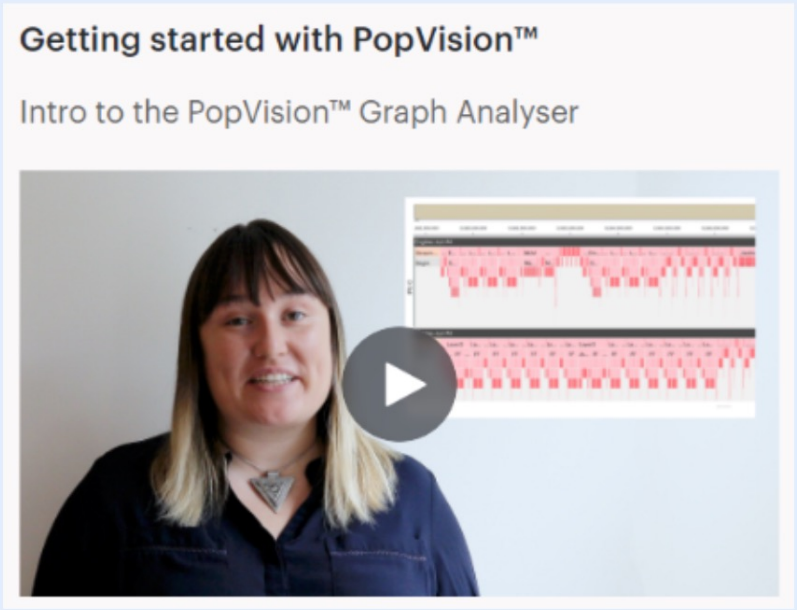
Dominique Beaini, Valence Discovery, a leader in AI-first drug design

POPVISION GRAPH ANALYSER

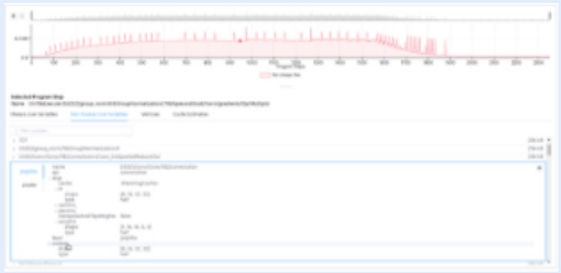
- You can use the PopVision Graph Analyser tool to debug IPU programs and generate reports on compilation and execution of the program.
- This tool can be downloaded from graphcore.ai/downloads
- There is a built-in help system within the tool for any questions you might have about producing and analysing reports.



PopVision Graph Analyser



Getting started video available on the developers portal



Several new features including:

- A new file format for the graph and execution profile, resulting in a 50% file size reduction
- Enhanced PopLibs debug information

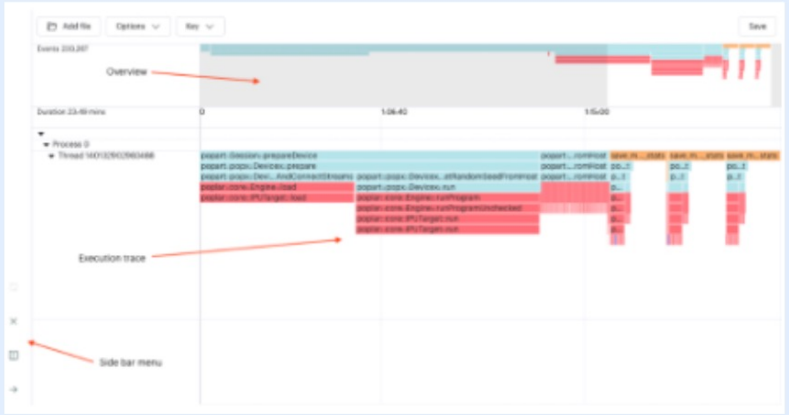
Liveness Report

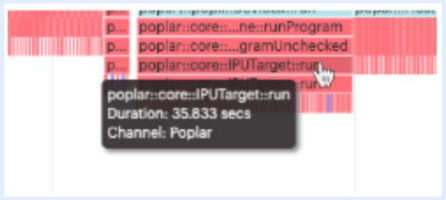
The debug information shown for a variable now displays enhanced information. For each variable that has debug information, you can now see the PopLibs API that created it, its arguments and its outputs.

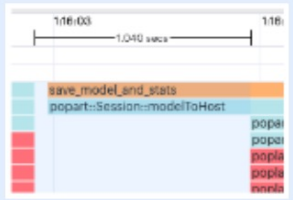
Enhanced debug information has been added to program steps. Program steps show Poplar and PopLibs debug information such as which PopLibs API created that program step, its arguments and its outputs.

Check out the integrated help or visit our developer portal for more information

PopVision System Analyser







Show the execution of the software on the host processor enabling users to identify bottlenecks in execution between CPU & IPU(s).

Provide profile insights as you scale models to multiple CPUs / IPUs.

The PopVision System Analyser allows developers to understand the execution of programs running on the host processor which control the IPU(s). The System Analyser shows the interaction between the host and the IPU(s) so that developers can understand where the bottlenecks are in the execution of their applications.

The PopVision System Analyser visualises the information collected by the PopVision Trace Instrumentation Library which is part of the Poplar SDK.

Visit our developer portal for more information and the latest documentation:

https://www.graphcore.ai/developer

CREATE PROFILE

```
(3.3.0+1403_poptorch) alext@bpod16:~/work/examples/tutorials/tutorials/pytorch/basics$ POPLAR_ENGINE_OPTIONS='{"autoReport.all":"true", "autoReport.directory":"./
report", "debug.allowOutOfMemory":"true", "profiler.includeFlopEstimates":"true"}' python walkthrough.py
epochs:   0%|                                                                                                  | 0/5 [00:00<?, ?it/s[
22:25:58.232] [poptorch:cpp] [warning] [DISPATCHER] Type coerced from Long to Int for tensor id 12                | 0/3750 [00:00<?, ?it/s]
Graph compilation: 100%|                                                                                        | 100/100 [00:39<00:00]
epochs: 100%|                                                                                                   | 5/5 [01:21<00:00, 16.21s/it]
/nethome/alext/venvs/poplar_sdk-ubuntu_20_04-3.3.0+1403-208993bbb7/3.3.0+1403_poptorch/lib/python3.8/site-packages/torch/nn/modules/module.py:1802: UserWarning: P
ositional args are being deprecated, use kwargs instead. Refer to https://pytorch.org/docs/master/generated/torch.nn.Module.html#torch.nn.Module.state_dict for de
tails.
  warnings.warn(
Graph compilation: 100%|                                                                                        | 100/100 [00:19<00:00]
Eval accuracy: 89.25%
Graph compilation: 100%|                                                                                        | 100/100 [00:09<00:00]
tensor([[-4.4754, -0.9084, -3.2791, -5.8905, -3.4738, -1.4554, -1.8643, -6.6169,
         -2.1170, -5.5300]])
IPU predicted class: Trouser
CPU predicted class: Trouser
```

PopVision® Graph Analyser [10.129.111.38 : /nethome/alext/work/examples/tutorials/tutorials/pytorch/basics/report/training]

- Summary
- Insights
- Memory Report
- Liveness Report
- Program Tree
- Operations Summary
- Operations Graph
- Execution Trace
- Reload Report
- Close Report
- Documentation
- Minimise

Graph Type - Total Memory | Breakdown - None | 201 | Options

Navigation 100%

Details | Compute Sets | Vertices | Exchanges | Variables

	Tile 201
Physical Tile Id	522
Memory Including Gaps	209 KiB
Memory Excluding Gaps	28.3 KiB
By Memory Region	
Non-interleaved	27.4 KiB
Interleaved	960 B
Overflowed	0 B
By Data Type	
Not Overlapped	
Variables	1.6 KiB
Constants	414 B
Control Code	2.4 KiB
Vertex Code	8.8 KiB
Internal Exchange Code	7.2 KiB
Host Exchange Code	640 B
Global Exchange Code	0 B
Vertex Instances	1.4 KiB

PopVision® Graph Analyser [10.129.111.38 : /nethome/alext/work/examples/tutorials/tutorials/pytorch/basics/report/training]

- Summary
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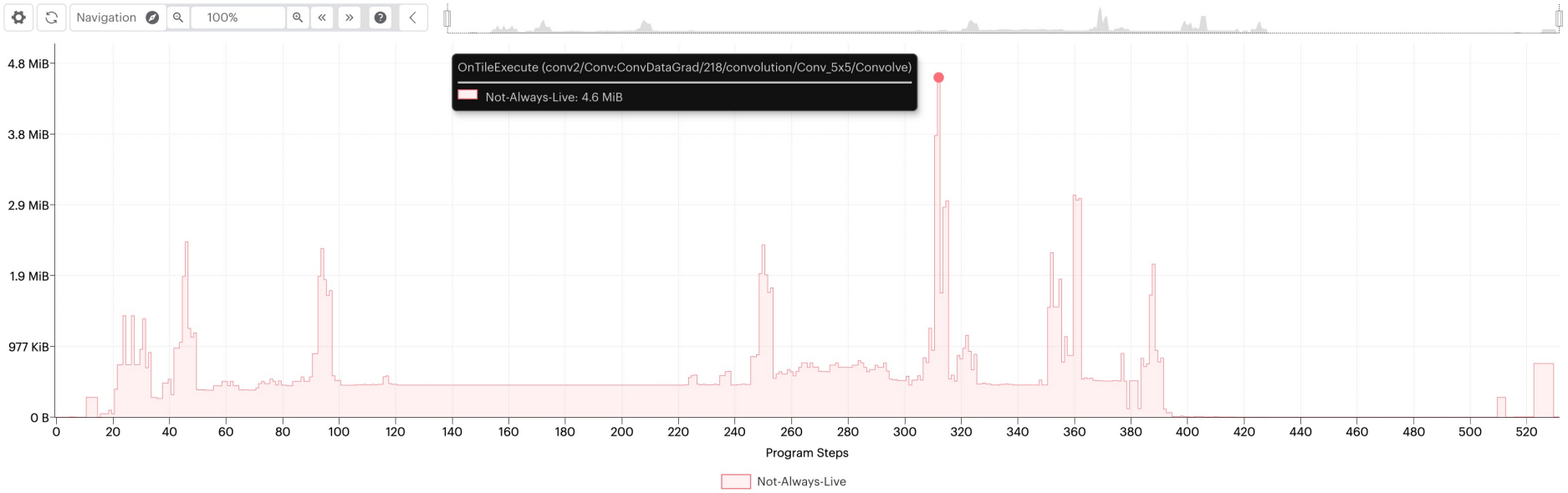
- Program Tree
- Operations Summary
- Operations Graph
- Execution Trace
- Reload Report
- Close Report
- Documentation
- Minimise

Filter steps | Select Source | Options

Navigation 100%



Selected Program Steps

Step 312 OnTileExecute (conv2/Conv:ConvDataGrad/218/convolution/Conv_5x5/Convolve)

Always-Live Variables | Not-Always-Live Variables | Vertices | Cycle Estimates | FLOP Estimates

Filter variables

Variable	All Tiles
Total	**29.3 MiB**
vertexCode	11.8 MiB
internalExchangeCode	8.5 MiB
controlCode	3.0 MiB
vertexInstanceState	1.9 MiB
hostExchangeCode	924 KiB
stack	535 KiB
instrumentationResults	402 KiB
Accl1__fc1.weight	380 KiB
fc1.weight	380 KiB
vertexFieldData	241 KiB
copyDescriptor	223 KiB
hostExchangePacketHeader	198 KiB


PopVision® Graph Analyser [10.129.111.38 : /nethome/alext/work/examples/tutorials/tutorials/pytorch/basics/report/training]
Summary
Insights
Memory Report
Liveness Report
Program Tree
Operations Summary
Operations Graph
Execution Trace
Reload Report
Close Report
Documentation
Minimise
Execution View - Flame & BSP
Navigation
58957%
All IPUs
Search
Options
1,480,000
1,490,000
1,500,000
1,510,000
1,520,000
1,530,000
1,540,000
1,550,000
1,560,000
1,570,000
IPU 0
Engine::run #0
100%
Summary
Details
Total Cycles 94,526 Total FLOPs 31,844,509
IPU
Proportions
Tile Utilisation
Stream Copy (Rx/Tx)
Global Exchange (Rx/Tx)
0
59.16%
0 B / 0 B
0 B / 0 B
One or more step types are hidden. These step types are excluded from the tile balance, tile utilisation, and cycle proportions shown and so the statistics may not be representative. Step types can be shown or hidden using the view options dropdown.

POPVISION TUTORIALS

Continued in the repositories below (follow the READMEs)

tutorials/pytorch/pipelining

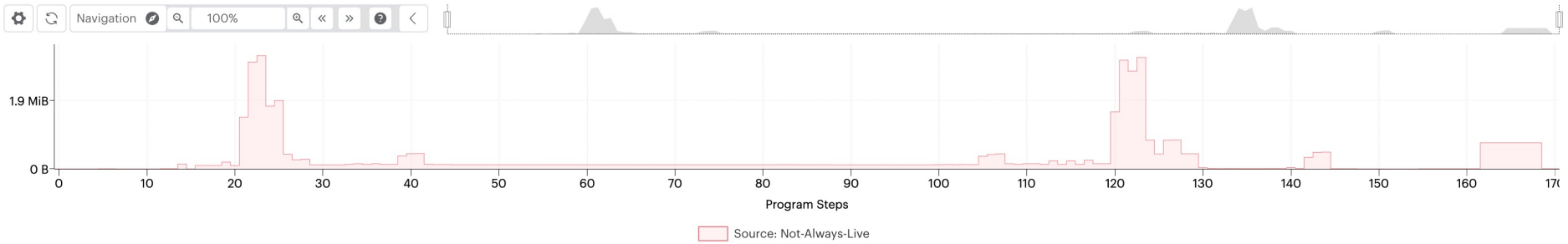
tutorials/popvision/system_analyser_instrumentation

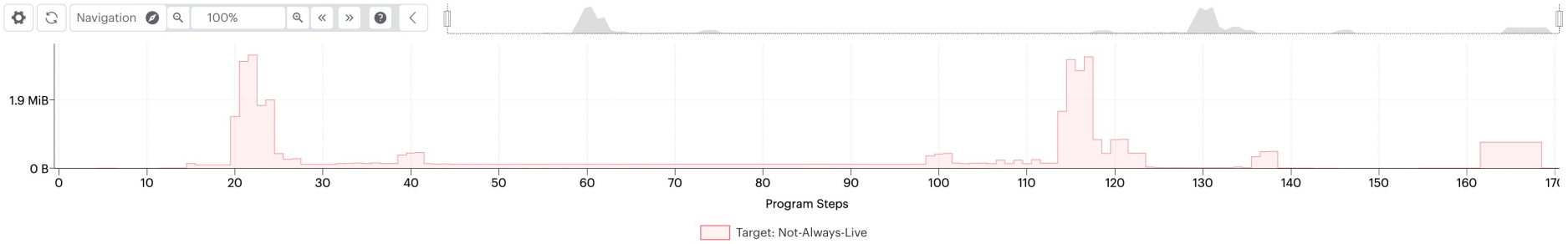
tutorials/tensorflow2/infeed_outfeed

PopVision® Graph Analyser [10.129.111.38 : /nethome/alext/work/examples/tutorials/tutorials/tensorflow2/infeed_outfeed/completed_code/report/tf_report__2023-07-25__01-03-33.553__93433 vs 10.129.111.38 : /nethome/alext/work/examples/tutorials/tutorials/tensor...

- Summary
- Memory Report
- Liveness Report
- Program Tree
- Operations Summary
- Execution Trace
- Swap Reports
- Reload Report
- Close Report
- Documentation
- Minimise

Filter steps | Select Source | Options





Selected Program Step

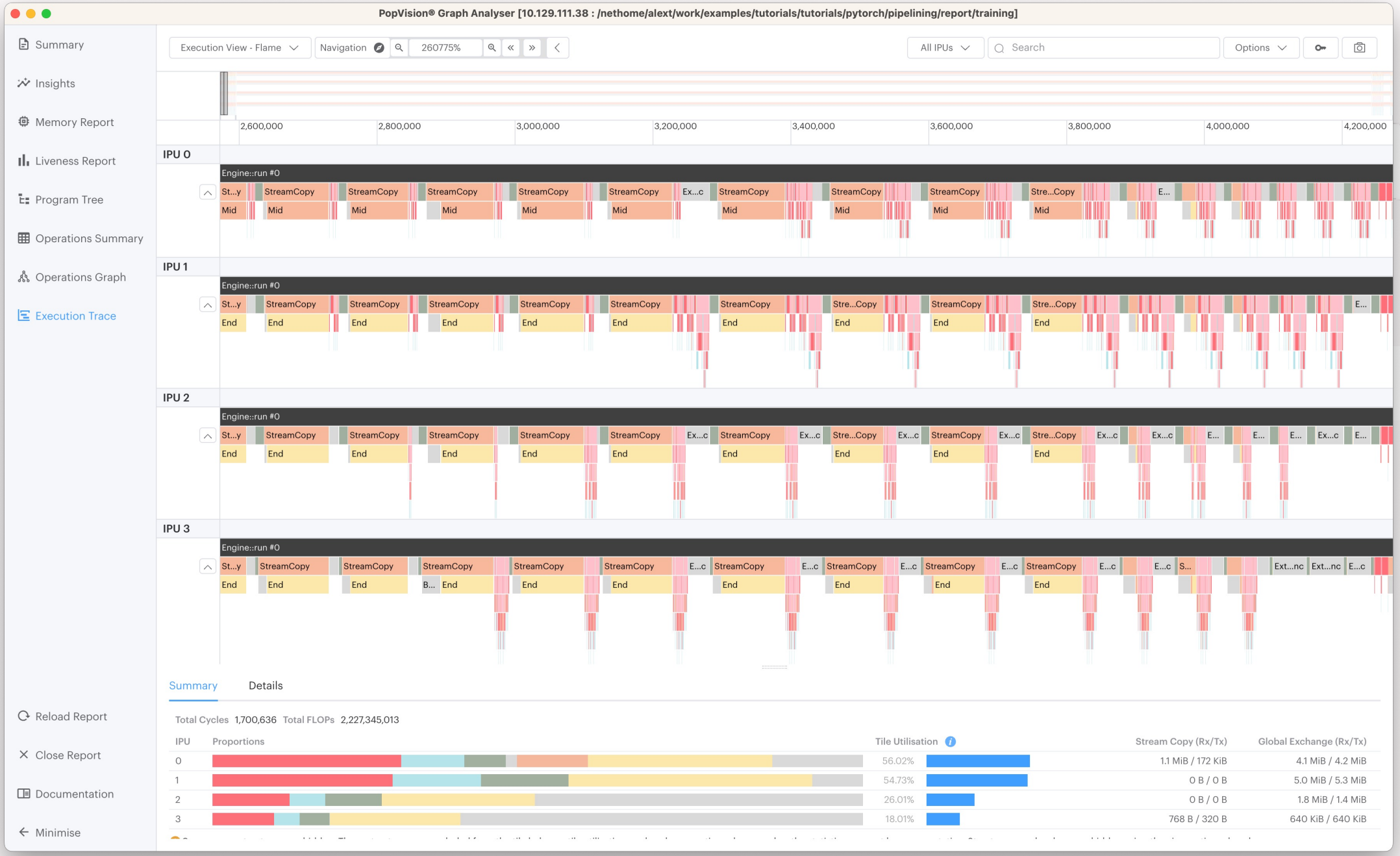
Name (source): None selected. Click on the graph to select a source program step

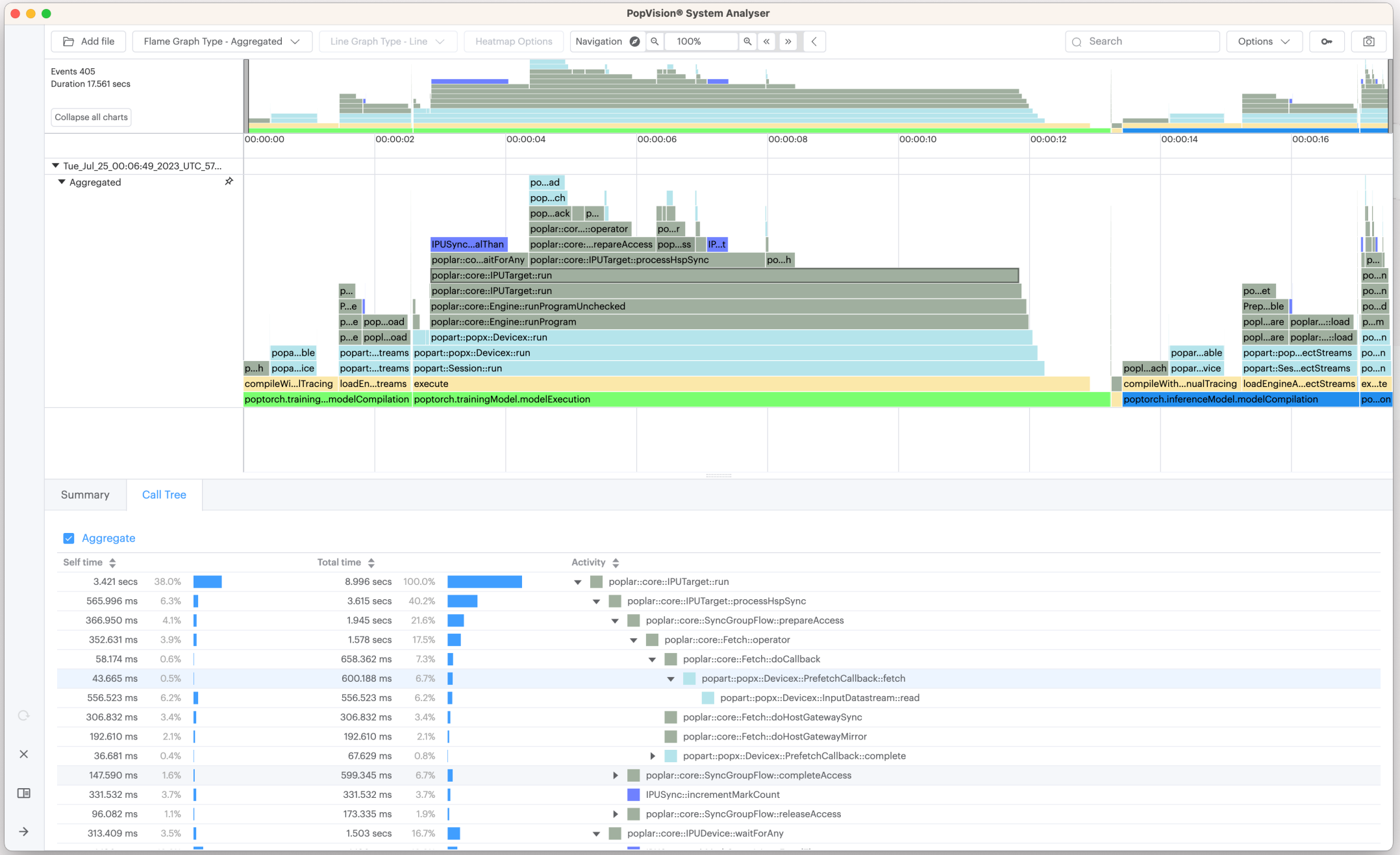
Name (target): None selected. Click on the graph to select a target program step

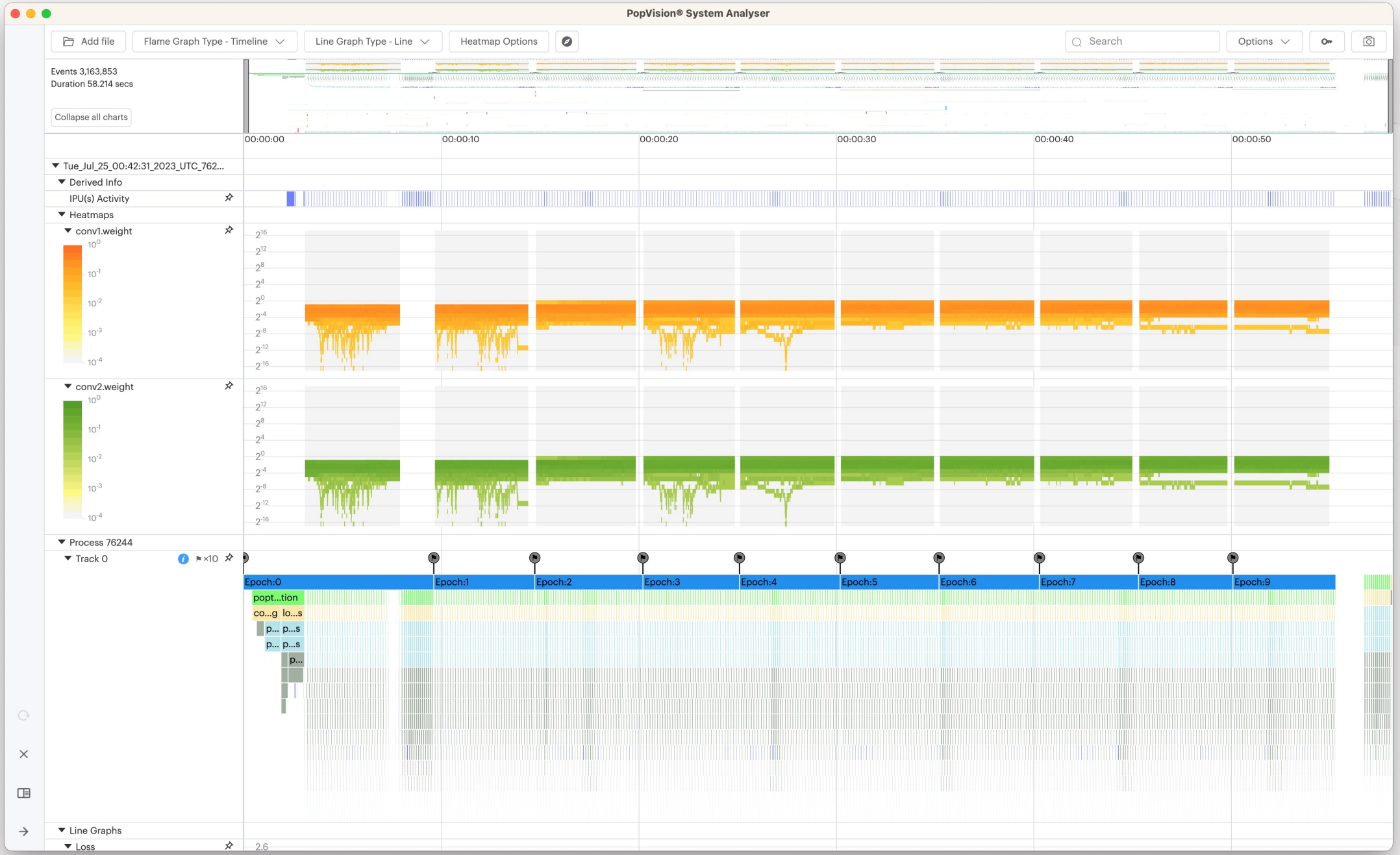
Always-Live Variables | Not-Always-Live Variables | Vertices | Cycle Estimates

Filter variables

Variable	Source: All Tiles	Target: All Tiles	Diff: All Tiles
Total	**11.3 MiB**	**11.2 MiB**	**-113 KiB**
vertexCode	6.0 MiB	6.0 MiB	-16 B (-0.00%)
controlCode	1.5 MiB	1.5 MiB	-37.7 KiB (-2.41%)
internalExchangeCode	1.2 MiB	1.1 MiB	-47.6 KiB (-3.99%)
hostExchangeCode	595 KiB	556 KiB	-39.2 KiB (-6.58%)
stack	540 KiB	529 KiB	-11.0 KiB (-2.04%)
vertexInstanceState	527 KiB	527 KiB	20 B (0.00%)
while/sequential/dense/MatMul/dot.35/rhs	392 KiB	—	-392 KiB (-100.00%)
sequential/dense/MatMul/dot/rhs	—	392 KiB	392 KiB (100.00%)
instrumentationResults	180 KiB	180 KiB	4 B (0.00%)
hostExchangePacketHeader	114 KiB	137 KiB	23.7 KiB (17.25%)


PopVision® Graph Analyser [10.129.111.38 : /nethome/alext/work/examples/tutorials/tutorials/pytorch/pipelining/report/training]
Summary
Insights
Memory Report
Liveness Report
Program Tree
Operations Summary
Operations Graph
Execution Trace
Reload Report
Close Report
Documentation
Minimise
Execution View - Flame
Navigation
260775%
All IPUs
Search
Options
2,600,000
2,800,000
3,000,000
3,200,000
3,400,000
3,600,000
3,800,000
4,000,000
4,200,000
IPU 0
IPU 1
IPU 2
IPU 3
Engine::run #0
Summary
Details
Total Cycles 1,700,636 Total FLOPs 2,227,345,013
IPU
Proportions
Tile Utilisation
Stream Copy (Rx/Tx)
Global Exchange (Rx/Tx)
0 56.02% 1.1 MiB / 172 KiB 4.1 MiB / 4.2 MiB
1 54.73% 0 B / 0 B 5.0 MiB / 5.3 MiB
2 26.01% 0 B / 0 B 1.8 MiB / 1.4 MiB
3 18.01% 768 B / 320 B 640 KiB / 640 KiB


PopVision® System Analyser
Add file
Flame Graph Type - Aggregated
Line Graph Type - Line
Heatmap Options
Navigation
100%
Search
Options
Events 405
Duration 17.561 secs
Collapse all charts
00:00:00
00:00:02
00:00:04
00:00:06
00:00:08
00:00:10
00:00:12
00:00:14
00:00:16
Tue_Jul_25_00:06:49_2023_UTC_57...
Aggregated
po...ad
pop...ch
pop...ack
p...
poplar::cor...::operator
po...r
IPUSync...alThan
poplar::core:...repareAccess
pop...ss
IP...t
poplar::co...aitForAny
poplar::core::IPUTarget::processHspSync
po...h
p...
poplar::core::IPUTarget::run
po...n
p...
poplar::core::IPUTarget::run
po...et
po...n
P...e
poplar::core::Engine::runProgramUnchecked
Prep...ble
po...d
p...e
pop...oad
poplar::core::Engine::runProgram
popl...are
poplar...::load
p...m
p...e
popl...oad
popart::popx::Devicex::run
popl...are
poplar:...::load
po...n
popa...ble
popart:...treams
popart::popx::Devicex::run
popar...able
popart::pop...ectStreams
po...n
p...h
popa...ice
popart:...treams
popart::Session::run
popl...ach
popar...vice
popart::Ses...ectStreams
po...n
compileWi...lTracing
loadEn...treams
execute
compileWith...nualTracing
loadEngineA...ectStreams
ex...te
poptorch.training...modelCompilation
poptorch.trainingModel.modelExecution
poptorch.inferenceModel.modelCompilation
po...on
Summary
Call Tree
Aggregate
Self time
Total time
Activity
3.421 secs 38.0% 8.996 secs 100.0% poplar::core::IPUTarget::run
565.996 ms 6.3% 3.615 secs 40.2% poplar::core::IPUTarget::processHspSync
366.950 ms 4.1% 1.945 secs 21.6% poplar::core::SyncGroupFlow::prepareAccess
352.631 ms 3.9% 1.578 secs 17.5% poplar::core::Fetch::operator
58.174 ms 0.6% 658.362 ms 7.3% poplar::core::Fetch::doCallback
43.665 ms 0.5% 600.188 ms 6.7% popart::popx::Devicex::PrefetchCallback::fetch
556.523 ms 6.2% 556.523 ms 6.2% popart::popx::Devicex::InputDatastream::read
306.832 ms 3.4% 306.832 ms 3.4% poplar::core::Fetch::doHostGatewaySync
192.610 ms 2.1% 192.610 ms 2.1% poplar::core::Fetch::doHostGatewayMirror
36.681 ms 0.4% 67.629 ms 0.8% popart::popx::Devicex::PrefetchCallback::complete
147.590 ms 1.6% 599.345 ms 6.7% poplar::core::SyncGroupFlow::completeAccess
331.532 ms 3.7% 331.532 ms 3.7% IPUSync::incrementMarkCount
96.082 ms 1.1% 173.335 ms 1.9% poplar::core::SyncGroupFlow::releaseAccess
313.409 ms 3.5% 1.503 secs 16.7% poplar::core::IPUDevice::waitForAny


PopVision® System Analyser
Add file
Flame Graph Type - Timeline
Line Graph Type - Line
Heatmap Options
Search
Options
Events 3,163,853
Duration 58.214 secs
Collapse all charts
00:00:00
00:00:10
00:00:20
00:00:30
00:00:40
00:00:50
Tue_Jul_25_00:42:31_2023_UTC_762...
Derived Info
IPU(s) Activity
Heatmaps
conv1.weight
conv2.weight
Process 76244
Track 0
Epoch:0
Epoch:1
Epoch:2
Epoch:3
Epoch:4
Epoch:5
Epoch:6
Epoch:7
Epoch:8
Epoch:9
popt...tion
co...g
lo...s
Line Graphs
Loss

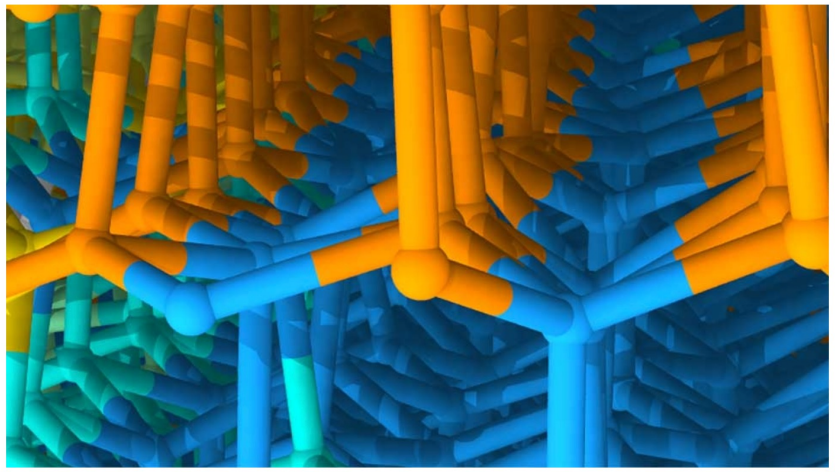
APPLY AND JOIN TODAY

Argonne Leadership Computing Facility

HOME / SCIENCE

Director's Discretionary Allocation Program

The ALCF Director's Discretionary program provides "start up" awards to researchers working to achieve computational readiness for for a major allocation award.



Molecular dynamics simulations based on machine learning help scientists learn about the movement of the boundary between ice grains (yellow/green/cyan) and the stacking disorder that occurs when hexagonal (orange) and cubic (blue) pieces of ice freeze together. Image: Henry Chan and Subramanian Sankaranarayanan, Argonne National Laboratory

Apply at alcf.anl.gov/science/directors-discretionary-allocation-program

general

charlieb 6:05 AM

Pleased to share with you all some new work from the Graphcore research team!

Our paper *Unit Scaling* introduces a new method for low-precision number formats, making FP16
We've managed to train BERT in these formats for the first time without loss scaling.

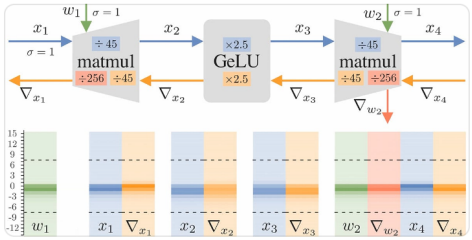
- You can find our blog post here: https://www.graphcore.ai/posts/simple-fp16-and-fp8-trainin
- Paperspace notebook (try it yourself!): https://ipu.dev/qXfm2a
- Arxiv paper: https://arxiv.org/abs/2303.11257

(& we were also featured on Davis Blalock's popular ML newsletter this week) (edited)

graphcore.ai

Simple FP16 and FP8 training with unit scaling

Unit Scaling is a new low-precision machine learning method able to train language models in FP16 and FP8 without loss scaling. (69 kB)



arXiv.org

Unit Scaling: Out-of-the-Box Low-Precision Training

We present unit scaling, a paradigm for designing deep learning models that simplifies the use of low-precision number formats. Training in FP16 or the recently proposed FP8 formats offers substantial efficiency gains, but can lack sufficient range for out-of-the-box training. Unit scaling addresses this by introducing a principled approach to model numerics: seeking unit variance of

Show more

8 8 7 1 1 1

Join at graphcore.ai/join-community

Tuesday, 11 June

1:00 PM	→ 1:15 PM	**Introduction**	15m
1:15 PM	→ 1:45 PM	**Graphcore BowPod64 Hardware**	30m
1:45 PM	→ 2:30 PM	**Software Stack: TensorFlow, PyTorch, and Poplar**	45m
2:30 PM	→ 2:45 PM	**Break**	15m
2:45 PM	→ 3:15 PM	**Porting applications with Poplar**	30m
3:15 PM	→ 4:00 PM	**How to use Bow Pod64@ ALCF**	45m

Wednesday, 12 June

1:00 PM	→ 1:45 PM	**Deep Dive on Graph neural networks and Large Language Models**	45m
1:45 PM	→ 2:15 PM	**Profiling with PopVision**	30m
2:15 PM	→ 2:30 PM	**Break**	15m
2:30 PM	→ 3:15 PM	**Hands-on session**	45m
3:15 PM	→ 4:00 PM	**Best Practices, Q&A**	45m

THANK YOU

Alexander Tsyplikhin
alext@graphcore.ai