Train deep learning models faster with Amazon SageMaker

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Agenda

- Challenges in training deep learning models
- Introducing Amazon SageMaker Training Compiler
- Demo
- Wrap-up and Q&A
Deep learning models have a size problem

Large datasets take a **long time to train**, creating a bottleneck

**Training costs** are an obstacle to experimentation and innovation
Optimizing for cost and speed is challenging

Infrastructure

Distributed training
Compilers offer efficiency gains

Convert high-level representation to hardware-optimized instructions
Enable more efficient use of hardware without scaling out or up
Dedicated compilers for inference offer performance gains of 25x
Compilers offer efficiency gains

Convert high-level representation to hardware-optimized instructions
Enable more efficient use of hardware without scaling out or up
Dedicated compilers for inference offer performance gains of 25x

No good built-in solution for training available
Compilation for deep learning training is a challenge

- Training time optimization
- Ease of use

- Low, easy
  - Default approach
- High, easy
- Low, difficult
  - Open source + third-party
- High, difficult
  - Customized & hand coded
Compilation for deep learning training is a challenge

- Low, easy
  - Default approach
- High, easy
  - Amazon SageMaker Training Compiler
- Low, difficult
  - Open source + third-party
- High, difficult
  - Customized & hand coded

Compilation for deep learning training is a challenge.
NEW
Amazon SageMaker Training Compiler

The fast and easy way to train large deep learning models on GPUs

GENERALLY AVAILABLE

Accelerate deep learning model training
Speed up training by as much as 50%

Minimal code changes required
Enable in minutes without any changes to workflow

Lower training costs
Free to use on SageMaker and additional savings from shortened training jobs
Specialized compilation accelerates training

Average training time per epoch
(RoBERTa base with SST2 dataset)

- PyTorch
- PyTorch with SageMaker Training Compiler

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Acceleration without workflow disruption

1. **Enable SageMaker Training Compiler** in existing training script with minimal code changes
2. **Amazon S3** - Store your training dataset
3. **Launch a SageMaker training job**
4. **SageMaker Training Compiler** - Automatically optimizes training job
   - Specialized kernels for SageMaker GPU instances
   - Data-flow optimizations with memory layout planning and sub-expression pruning
   - Graph-level optimizations including operator fusion and memory planning
5. **Trained model in Amazon S3, ready to deploy**
Deep learning compiler architecture

- **Framework**: PyTorch, TensorFlow

  - **Compiler frontend**
    - High-level IR (Graph IR)
      - Hardware independent optimizations
      - Optimizations on computation and control flow
      - E.g., static memory planning, operator fusion

  - **Compiler backend**
    - Low-level IR
      - Hardware specific optimizations
      - E.g., memory latency hiding
      - Hardware code generation

- **Hardware (SM GPUs)**
  - ml.g4dn, ml.p3, and ml.p4d instances on SageMaker
Key DL compiler optimization: operator fusion

Op. 1 → Op. 2 → Op. 3 → ...

Computation graph

Kernel launches

Hardware
Key DL compiler optimization: operator fusion

Fused operator

Computation graph

Kernel launches

Hardware

Hardware
SageMaker Training Compiler can be enabled in minutes

```python
from sagemaker.huggingface import HuggingFace
from sagemaker.huggingface import TrainingCompilerConfig

pytorch_estimator = HuggingFace(entry_point='train.py',
instance_count=1,
instance_type='ml.p3.2xlarge',
transformers_version='4.11.0',
pytorch_version='1.9.0',
compiler_config=Training CompilerConfig(),
hyperparameters = {'epochs': 20,
                   'batch-size': 64,
                   'learning-rate': 0.1}

pytorch_estimator.fit({'train': 's3://my/path/to/my/training/data',
                       'test': 's3://my/path/to/my/test/data'})
```
Up to 50% speedup with Training Compiler

Training sample throughput\(^1\) (samples/second)

<table>
<thead>
<tr>
<th>Model</th>
<th>PyTorch</th>
<th>SageMaker with Training Compiler</th>
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</thead>
<tbody>
<tr>
<td>BERT base</td>
<td>73</td>
<td>96</td>
</tr>
<tr>
<td>distilBERT</td>
<td>137</td>
<td>170</td>
</tr>
<tr>
<td>RoBERTa base</td>
<td>62</td>
<td>84</td>
</tr>
<tr>
<td>GPT-2</td>
<td>47</td>
<td>81</td>
</tr>
</tbody>
</table>

Reduction in billable time:
- BERT base: 38%
- distilBERT: 26%
- RoBERTa base: 27%
- GPT-2: 54%

\(^1\) Test parameters: ml.p3.2xlarge, PyTorch with Hugging Face Trainer API, 25 epochs, sequence length of 512
Baseline used the Hugging Face AWS Deep Learning Container from Amazon ECR

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SageMaker Training Compiler accelerates the most popular NLP models

- bert-base-uncased
- bert-large-uncased
- roberta-base
- gpt2
- bert-base-cased
- xlm-roberta-base
- bert-base-chinese
- roberta-large
- distilbert-base-uncased
- distilbert-base-uncased-finetuned-sst-2-English
- cl-tohoku/bert-base-japanese-whole-word-masking
- bert-base-multilingual-cased
- distilgpt2
- albert-base-v2
- gpt2-large
Guidewire is the platform P&C insurers trust to engage, innovate, and grow efficiently; the company combines digital, core, analytics, and AI to deliver its platform as a cloud service, and it enables its customers to do advanced analytics and machine learning for their industry-specific workloads; more than 450 insurers, from new ventures to the largest and most complex in the world, run on Guidewire.

One of Guidewire’s services is to help customers develop cutting-edge NLP models for applications like risk assessment and claims operations. Amazon SageMaker Training Compiler is compelling because it offers time and cost savings to our customers while developing these NLP models. We expect it to help us reduce training time by more than 20% through more efficient use of GPU resources. We are excited to implement SageMaker Training Compiler in our NLP workloads, helping us to accelerate the transformation of data to insight for our customers.”

Matt Pearson, Principal Product Manager, Analytics and Data Services, Guidewire Software
Leading music data company providing data, tools, and services that enrich the way we experience music; the largest in the world with over 80 million users and over 8 million distinct lyrics

We are always looking for ways to accelerate training time while also lowering training costs, which is why we are excited about Amazon SageMaker Training Compiler. SageMaker Training Compiler provides more efficient ways to use GPUs during the training process and, with the seamless integration between SageMaker Training Compiler, PyTorch, and high-level libraries like Hugging Face, we have seen a significant improvement in training time of our transformer-based models – going from weeks to days – as well as lower training costs.”

Loreto Parisi, AI Engineering Director, Musixmatch
Quantum Health is on a mission to make healthcare navigation smarter, simpler, and more cost-effective for everyone; they use Amazon SageMaker for use cases like text classification, text summarization, predictive models, classification problems, and Q&A to help the Quantum team and the members they serve.

Iterating with NLP models can be a challenge because of their size; long training times bog down workflows, and high costs can discourage our team from trying larger models that might offer better performance. Amazon SageMaker Training Compiler is exciting because it has the potential to alleviate these frictions. Achieving a speedup with SageMaker Training Compiler is a real win for our team that will make us more agile and innovative moving forward.”

Jorge Lopez Grisman, Senior Data Scientist, Quantum Health
Demo
SageMaker Training Compiler in summary

- Accelerate DL model training by up to 50%
- Free to use on Amazon SageMaker
- Generally available in us-east-1, us-east-2, us-west-2, eu-west-1
Roadmap

Launch

• Tested with HF encoder models
• Hugging Face DLCs on SM
• Native distributed data parallelism

2022

• More testing with more models
• PT, TF DLCs on SM
• SM distributed training library support
Resources

• Example notebooks

• Technical documentation
  https://docs.aws.amazon.com/sagemaker/latest/dg/training-compiler.html

• Amazon SageMaker Model Training web page
  https://aws.amazon.com/sagemaker/train
Thank you!

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