RunInference: Machine Learning Inferences in Beam

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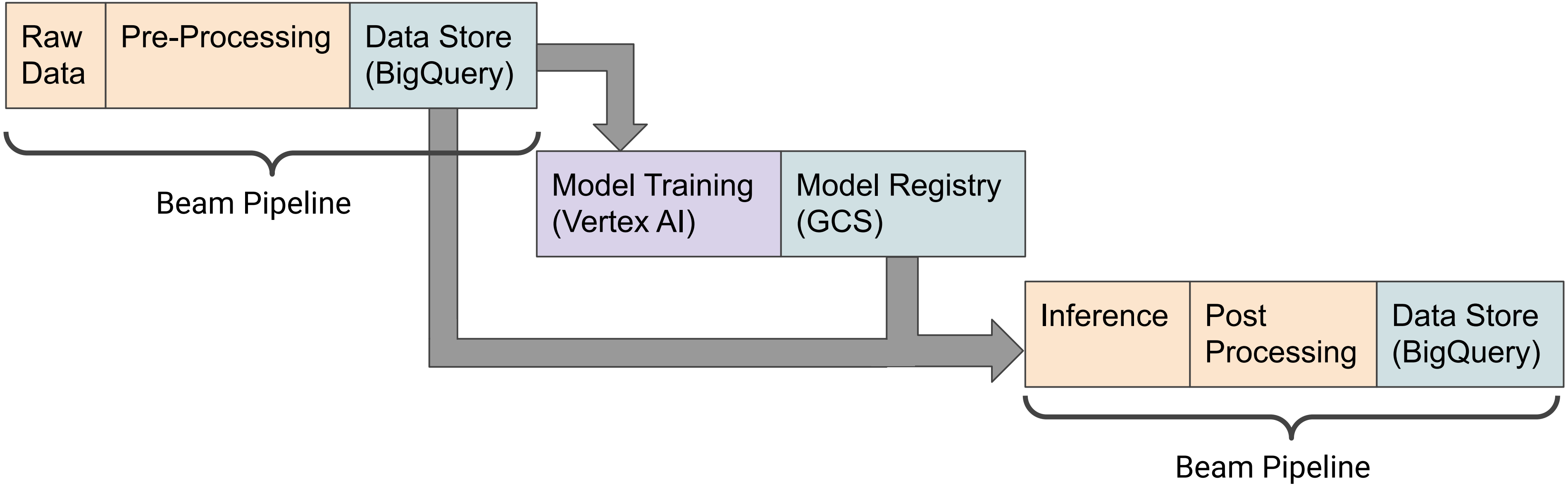
BEAM SUMMIT

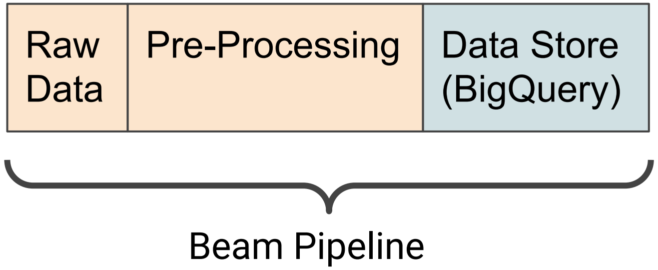
Agenda

1. Background: ML lifecycle, and previous limitations in Beam
2. RunInference: Machine learning inferences in Beam
3. RunInference API: Usage, patterns, and features
4. RunInference in the future
5. RunInference demo

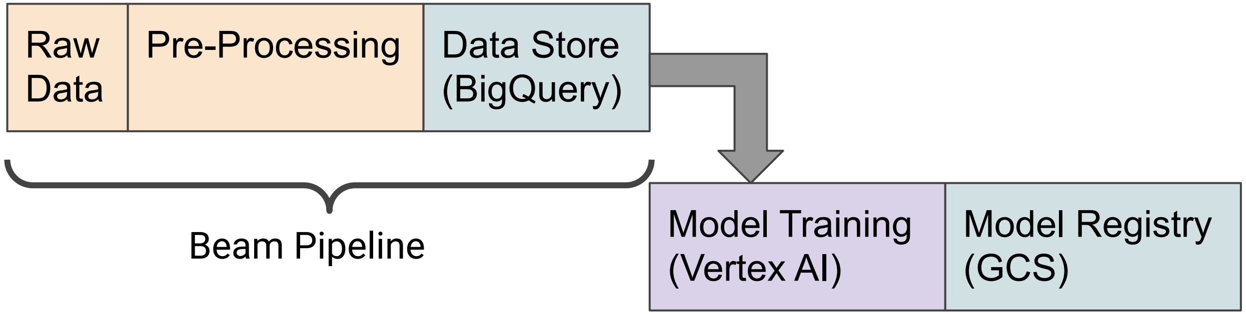
Typical Machine Learning Lifecycle



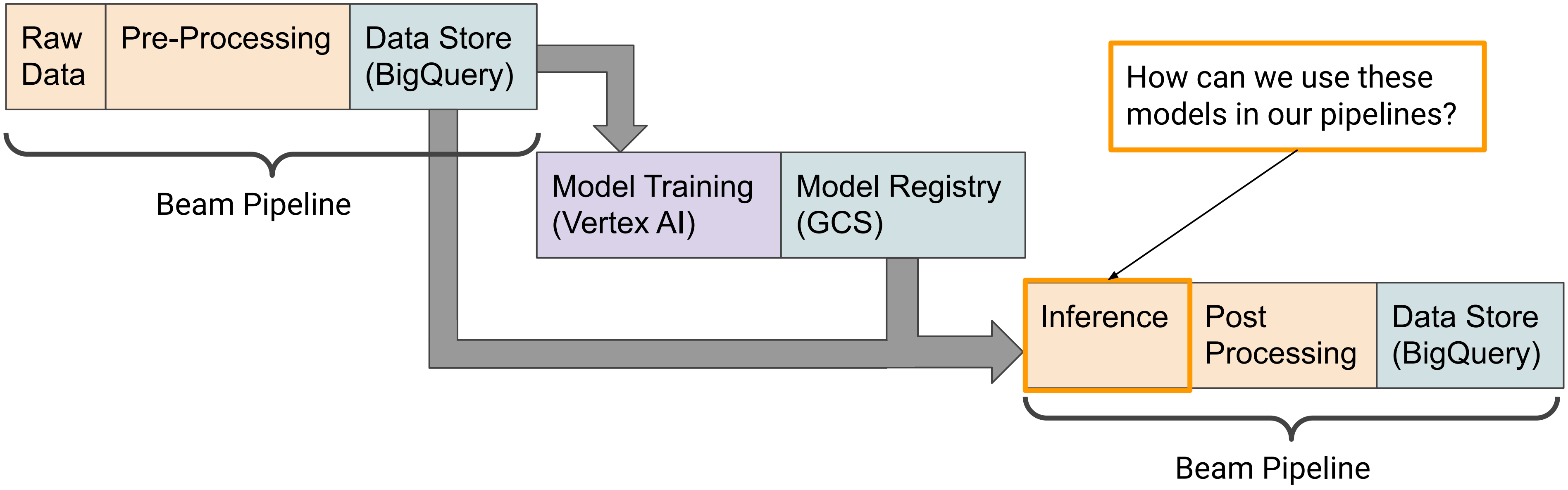
Typical Machine Learning Lifecycle



Typical Machine Learning Lifecycle



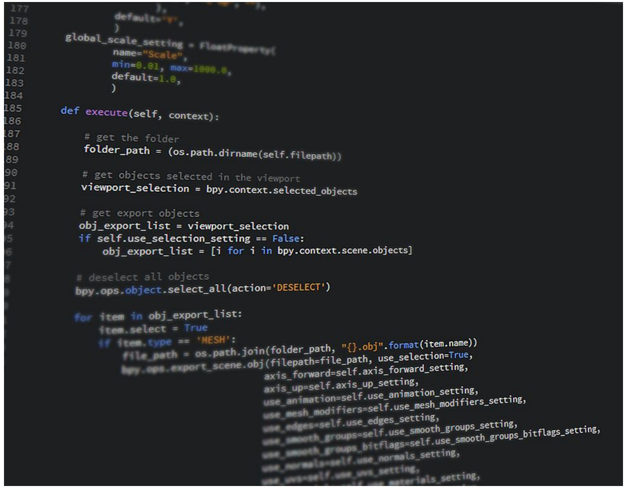
Typical Machine Learning Lifecycle



Before Beam 2.40.0: No native support for making inferences

Most Machine Learning frameworks

Users must write a custom DoFn



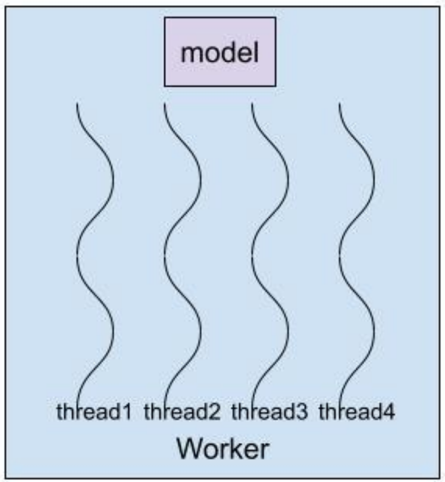
TensorFlow

Users use RunInference from the ***tfx_bsl*** utility

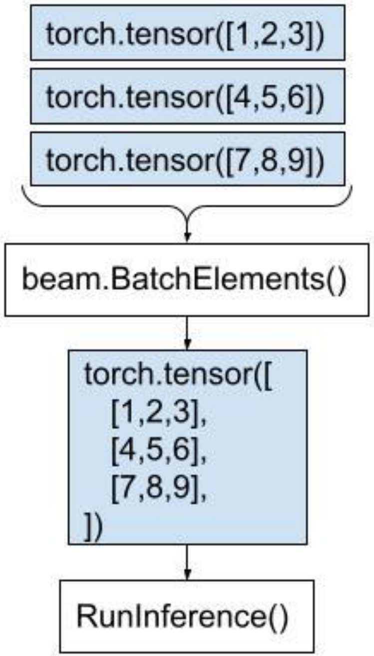
TensorFlow

RunInference: A new Beam transform to run ML inferences

Shared class



Dynamic Batching



- Key forwarding
- Processing the output
- Standard Metrics
- GPUs

Supported Frameworks

PyTorch

scikit learn

TensorFlow*

* TF support via the tensorflow/tfx-bsl repo. A migration to Beam is anticipated soon.

How to use RunInference

```
from apache_beam.ml.inference.base import RunInference

with pipeline as p:
   predictions = ( p | beam.ReadFromSource('a_source')
                     | RunInference(ModelHandler))
```

ModelHandlers

```
from apache_beam.ml.inference.sklearn_inference import SklearnModelHandlerNumpy

from apache_beam.ml.inference.sklearn_inference import SklearnModelHandlerPandas

from apache_beam.ml.inference.pytorch_inference import PytorchModelHandlerTensor

from apache_beam.ml.inference.pytorch_inference import PytorchModelHandlerKeyedTensor

model_handler = SklearnModelHandlerNumpy(model_uri='model.pkl',

                                         model_file_type=ModelFileType.JOBLIB)

model_handler = PytorchModelHandlerTensor(state_dict_path='linear_regression.pth',

                                          model_class=PytorchLinearRegression,

                                          model_params={'input_dim': 1, 'output_dim': 1})
```

KeyedModelHandler

```
from apache_beam.ml.inference.base import KeyedModelHandler
keyed_model_handler = \
    KeyedModelHandler(PytorchModelHandlerTensor(...))
with pipeline as p:
   data = p | beam.Create([
      ('img1', np.array[[1,2,3],[4,5,6],...]),
      ('img2', np.array[[1,2,3],[4,5,6],...]),
      ('img3', np.array[[1,2,3],[4,5,6],...]),
   ])
   predictions = data | RunInference(keyed_model_handler)
```

Creating Ensembles

- A/B Pattern
- Sequential Pattern

A/B Pattern

```
with pipeline as p:
    data = p | 'Read' >> beam.ReadFromSource('a_source')
    model_a_predictions = data | RunInference(ModelHandlerA)
    model_b_predictions = data | RunInference(ModelHandlerB)
```

Sequential Pattern

```
with pipeline as p:
    data = p | 'Read' >> beam.ReadFromSource('a_source')
    model_a_predictions = data | RunInference(ModelHandlerA)
    model_b_predictions = (
                model_a_predictions | RunInference(ModelHandlerB))
```

PredictionResult

```
class PostProcessor(beam.DoFn):
    def process(self, element: Tuple[str, PredictionResult]):
        key, prediction_result = element
        inputs = prediction_result.example
        predictions = prediction_result.inference

        # Post-processing logic
        result = ...
        yield (key, result)

with pipeline as p:
    output = (
        p | 'Read' >> beam.ReadFromSource('a_source')
          | 'PytorchRunInference' >> RunInference(KeyedModelHandler)
          | 'ProcessOutput' >> beam.ParDo(PostProcessor()))
```

Metrics

- Namespaces
- num_inferences
- Count, min, max, mean of
  - batch_size
  - msec_per_batch
  - inference_batch_latency_micro_secs
  - inference_request_batch_byte_size
  - inference_request_batch_size
  - load_model_latency_milli_secs
  - model_byte_size

Metrics in the UI of a Dataflow job

Custom counters

Filter mean Filter by counter name, value or step

Counter name	Value	Step
batch_size_MEAN	1	PyTorch RunInference/.../
msec_per_batch_MEAN	14,146	PyTorch RunInference/.../
inference_batch_latency_micro_secs_MEAN	13,625,472	PyTorch RunInference/.../
inference_request_batch_byte_size_MEAN	16	PyTorch RunInference/.../
inference_request_batch_size_MEAN	1	PyTorch RunInference/.../
load_model_latency_milli_secs_MEAN	6,347	PyTorch RunInference/.../
model_byte_size_MEAN	402,484,199	PyTorch RunInference/.../

RunInference in the future

- Optional batching
- Streaming with side inputs
- Integration with remote services (e.g. Vertex AI)

More frameworks! Please help contribute!

Coming soon!

XGBoost

JAX

And more!

Related Links

- Machine Learning in Beam
  https://beam.apache.org/documentation/sdks/python-machine-learning/
- RunInference Transform
  https://beam.apache.org/documentation/transforms/python/elementwise/runinference/
- Pipeline Examples
  https://github.com/apache/beam/tree/master/sdks/python/apache_beam/examples/inference
- RunInference Python Documentation
  https://beam.apache.org/releases/pydoc/current/apache_beam.ml.inference.html#apache_beam.ml.inference.RunInference

Thank you!

Demo time!