# BEAM
## SUMMIT

# Write your own model handler for Run Inference

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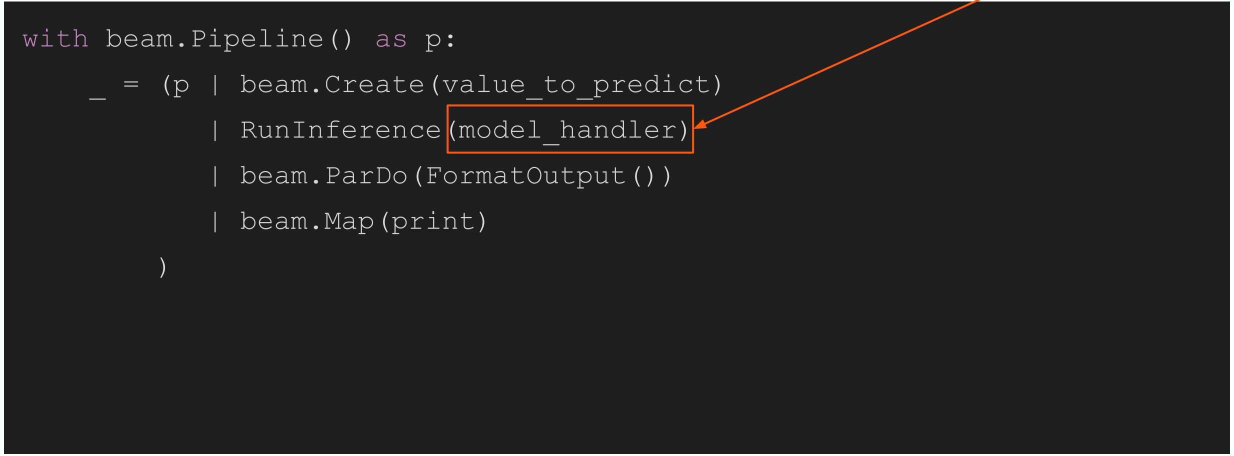
# About me

- Based in Durham, NC
- Contributions:
  - Beam Go SDK
  - Python/ML
- Cricket, F1

# Why do we need a model handler?

Parameter to RunInference Transform



```
with beam.Pipeline() as p:
    _ = (p | beam.Create(value_to_predict)
           | RunInference(model_handler)
           | beam.ParDo(FormatOutput())
           | beam.Map(print)
        )
```

# What is a model handler?

- Class with defined input and output types

The base class looks like

```
class ModelHandler(Generic[ExampleT, PredictionT, ModelT]):
```

where ExampleT - type of Input (Numpy)

PredictionT - type of output

ModelT - type of Model class (tf.Module)

# What is a model handler?

- Specific Framework
- Avoids repetitive steps like:
  - loading and initializing a model
  - defining inference function
- Automatic model refresh with Beam side inputs.
- Share model between processes
- Write once to do inference with a single line of code.

# Key components of a Model Handler

- input/output types
- load_model(self)
  - load and return the model
- run_inference(self, batch, inference_args)
  - perform run inference inference
- update_model_path(self, new_path)
  - replace the old model with newly trained model
- get_num_bytes(self)
  - return the size of batch of elements. (Used internally by RunInference)

Reference: https://github.com/apache/beam/blob/639dcf70b27b667cca0816a0d35ef7fb992f758c/sdks/python/apache_beam/ml/inference/base.py#L122

# Let's write our model handler

Step 1: Decide the input types to support. Eg: Numpy, tensors, etc.

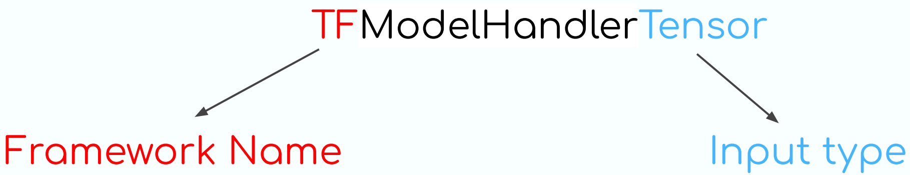
- Let's take tensorflow tensors for the example

Step 2: Extend the base ModelHandler class

# Let’s write our model handler

## Example:

Let’s write a TensorFlow model handler that could take *tf.Tensor* input, output as *PredictionResult* and *tf.Module* as the model class



```
class TFModelHandlerTensor(ModelHandler[tf.Tensor, PredictionResult, tf.Module]):
```

where PredictionResult is a NamedTuple that stores example and inference for that example.

# Let’s write our model handler

Step 3: Figure out what would be needed to load the model

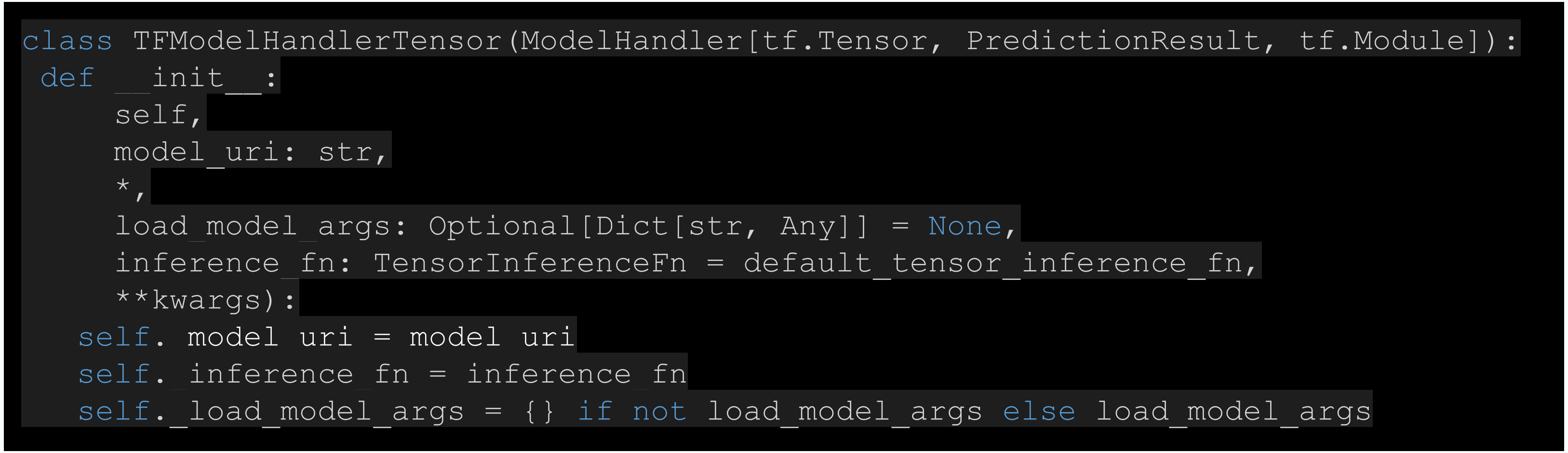
In case of TensorFlow we could load the model in two ways:

1. By using an model URI (either from TensorFlow Hub or other filesystem)
2. Path to weights and a function to create the model

Let’s just focus on point 1) for the sake of an example

# Let’s write our model handler

Example:

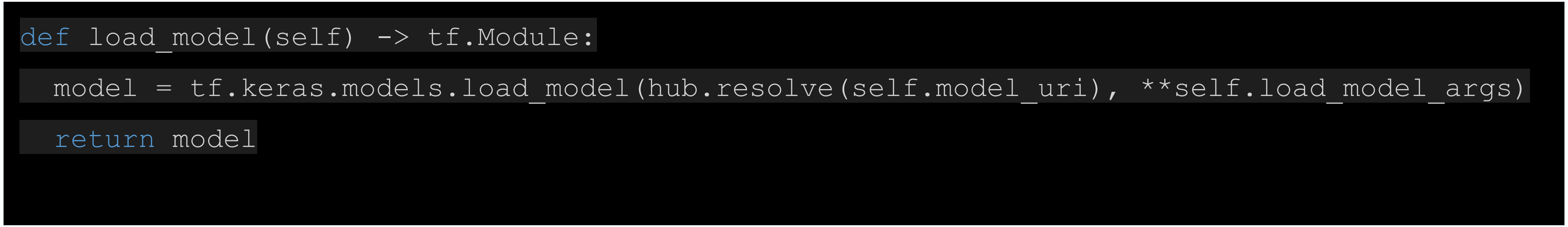


```python
class TFModelHandlerTensor(ModelHandler[tf.Tensor, PredictionResult, tf.Module]):
 def __init__:
      self,
      model_uri: str,
      *,
      load_model_args: Optional[Dict[str, Any]] = None,
      inference_fn: TensorInferenceFn = default_tensor_inference_fn,
      **kwargs):
   self._model_uri = model_uri
   self._inference_fn = inference_fn
   self._load_model_args = {} if not load_model_args else load_model_args
```

# Let’s write our model handler

## Step 4: Let’s write our load model function

It should load and return the model from this method



```
def load_model(self) -> tf.Module:
  model = tf.keras.models.load_model(hub.resolve(self.model_uri), **self.load_model_args)
  return model
```

# Let’s write our model handler

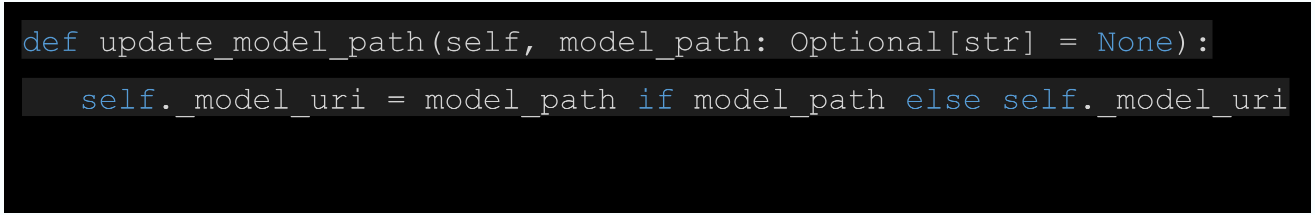
## Step 5: Run Inference

```python
def run_inference(
     self,
     batch: Sequence[numpy.ndarray],
     model: tf.Module,
     inference_args: Optional[Dict[str, Any]] =None
 ) -> Iterable[PredictionResult]:
  inference_args = {} if not inference_args else inference_args
  return self._inference_fn(model, batch, inference_args,self._model_uri)


def default_tensor_inference_fn(
   model: tf.Module,
   batch: Sequence[tf.Tensor],
   inference_args: Dict[str, Any],
   model_id: Optional[str] =None) -> Iterable[PredictionResult]:
 vectorized_batch = tf.stack(batch, axis=0)
 predictions = model(vectorized_batch, **inference_args)
 return utils._convert_to_result(batch, predictions, model_id)
```

# Let’s write our model handler

## Step 6: Automatic model refresh



```
def update_model_path(self, model_path: Optional[str] = None):
    self._model_uri = model_path if model_path else self._model_uri
```

*Talk on ML model updates by Anand Inguva in Horizon at 15:30.*

# Other methods for model handler

- get_metrics_namespace
  - returns a string namespace
- get_resource_hints
  - returns resource hints as a dictionary for model handler
- batch_elements_kwargs
  - return a dictionary {‘min_batch_size’: 1, ‘max_batch_size’=32}
- share_model_across_processes
  - return a boolean value
  - for large models

```
class TFModelHandlerTensor(ModelHandler[tf.Tensor,
PredictionResult, tf.Module]):
  def __init__(

     self,
     model_uri: str,
     *,
     load_model_args: Optional[Dict[str, Any]] = None,
     inference fn: TensorInferenceFn =
default tensor inference_fn,
     **kwargs):
   self. model uri = model uri
   self._inference_fn = inference_fn
   self. load model_args = {} if not load_model_args else
load_model_args

  def load_model(self) -> tf.Module:
    model =
tf.keras.models.load_model(hub.resolve(self._model_uri),
**self._load_model_args)
    return model
```

```
  def run_inference(
     self,
     batch: Sequence[numpy.ndarray],
     model: tf.Module,
     inference_args: Optional[Dict[str, Any]] = None
   ) -> Iterable[PredictionResult]:
    inference_args = {} if not inference_args else
inference_args
    return self._inference_fn(model, batch, inference_args,
self._model_uri)

  def update_model_path(self, model_path: Optional[str] =
None):
    self._model_uri = model_path if model_path else
self._model_uri

  def get_num_bytes(self, batch: Sequence[numpy.ndarray]) ->
int:
    return sum(sys.getsizeof(element) for element in batch)
```

# Let’s write our model handler

Example pipeline:

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

test_examples = [20, 40, 60, 90]
value_to_predict = tf.constant(test_examples, dtype=tf.float32)

model_handler = TFModelHandlerTensor(saved_model_path)

with beam.Pipeline() as p:
   _ = (p | beam.Create(value_to_predict)
          | RunInference(model_handler)
          | beam.ParDo(FormatOutput())
          | beam.Map(print)
       )
```

# Keyed Model Handler

As simple as

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

model_handler = KeyedModelHandler(TFModelHandlerTensor)
```

# Current model handlers

- onnx
- pytorch
- sklearn
- tensorflow
- tensorrt
- xgboost

*Coming soon…*

- Hugging Face
- Vertex AI

Reference: https://github.com/apache/beam/tree/master/sdks/python/apache_beam/ml/inference

# Related Resources

- Demo Notebook
- RunInference in Beam talk from Beam Summit 2022
- Example notebook with TensorFlow Model Handler
- Example ML notebooks
- Design Doc of Run Inference API

# QUESTIONS?

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