Building data pipelines with `tf.data`

https://www.tensorflow.org/guide/data

https://www.tensorflow.org/guide/data_performance

Why care about data **pipelines**?

- Machine learning models are data-hungry
- Before data is fed to an ML model it should be:
  - Shuffled
  - Batched
  - Batches to be available before the current epoch is finished

What is `tf.data`?

`tf.data` is a module by TensorFlow that:

- Helps us to build data input pipelines which are:
  - Scalable
  - Simple
  - Reusable

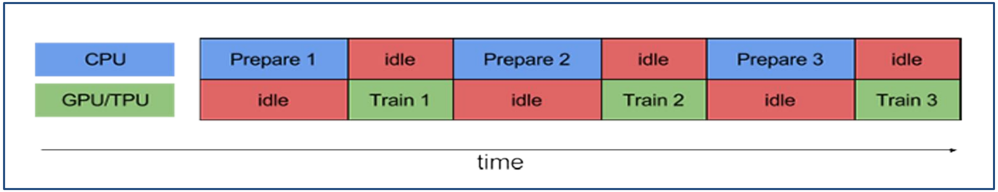
What is `tf.data`?

`tf.data` is a module by TensorFlow that:

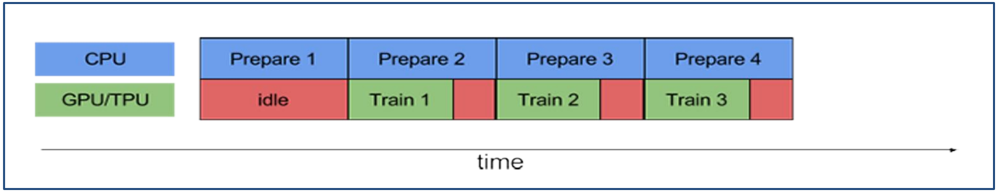
- Helps us to build data input pipelines
- Allows us to define the data input pipelines with a lot of dynaminicity
    - For example, the data input pipelines for image and text can be completely different.
    - `tf.data` gives you *programmable interfaces* to aid your use ca ses.

Salient features of `tf.data`

- Efficient *pipelining* to reduce any additional time it takes to stream y our data to the model



Processes running without pipelines



Processes running with pipelines

Salient features of `tf.data`

- Efficient *pipelining* to reduce any additional time it takes to stream y our data to the model ⟵ `tf.data.Dataset.prefetch()`
- *Parallelizable* function mapping to your data (*Parallelizable* data transformation) ⟵ `tf.data.Dataset.map(preproc_fn)`

What makes `tf.data` different from others?

- `tf.data` can *dynamically* decide the level of parallelism to use (`tf.data.experimental.AUTOTUNE`).
- For small datasets, you can `cache` the subsequent batches to be av ailable after the current epoch.

Building data pipelines with `tf.data`

- Use `tf.data.Dataset`.

```
# FashionMNIST data along with images and labels
(train, test) = tf.keras.datasets.fashion_mnist.load_data()

# Create tf.data.Dataset!
X_train, y_train = train
train_dataset = tf.data.Dataset.from_tensor_slices((X_train, y_train))
X_test, y_test = test
test_dataset = tf.data.Dataset.from_tensor_slices((X_test, y_test))
```

```
train_dataset

<TensorSliceDataset shapes: ((28, 28), ()), types: (tf.uint8, tf.uint8)>
```

Building data pipelines with `tf.data`

- Use `tf.data.Dataset`.
- Shuffle, repeat, batch and prefetch the data.

```
train_dataset = train_dataset.\
    shuffle(buffer_size=1000).\
    repeat().\
    batch(256).\
    prefetch(buffer_size=1000)
```

Verify shapes!

```
for (images, labels) in train_dataset.take(1):
    pass

print(images.shape) # TensorShape([256, 28, 28])
```

Building data pipelines with `tf.data`

- Use `tf.data.Dataset`.
- Shuffle, repeat, batch and prefetch the data.
- Define, compile and train your model! (optional)

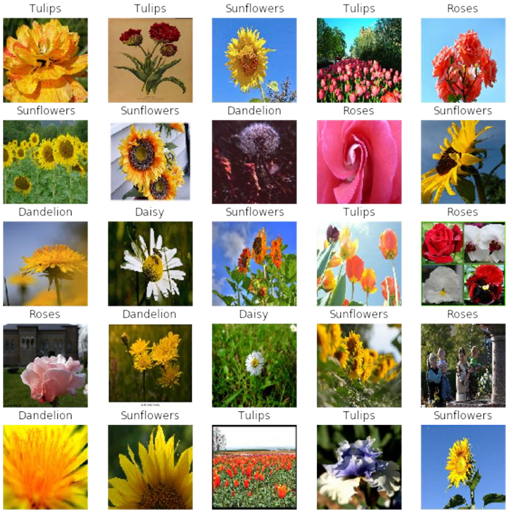
```
# Define and compile a model
model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(input_shape=(28, 28)),
  tf.keras.layers.Dense(128, activation='relu'),
  tf.keras.layers.Dropout(0.2),
  tf.keras.layers.Dense(10, activation='softmax')
])

model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])
```

```
model.fit(train_dataset,
    steps_per_epoch=len(X_train)//256,
    epochs=5,
    validation_data=test_dataset.batch(256))
```

`tf.data` + `ImageDataGenerator`

We will use the **Flowers dataset.**



tf.data + ImageDataGenerator

- Initialize `ImageDataGenerator` with the augmentations.

```
train_aug = ImageDataGenerator(
    rotation_range=30,
    zoom_range=0.15,
    width_shift_range=0.2,
    height_shift_range=0.2,
    shear_range=0.15,
    horizontal_flip=True,
    fill_mode="nearest")
```

tf.data + ImageDataGenerator ❤

- Initialize `ImageDataGenerator` with the augmentations.
- Wrap the generator with `tf.data`.

```
train_set = tf.data.Dataset.from_generator(
    lambda: train_aug.flow_from_directory(flowers,
            class_mode="categorical",
            target_size=(224, 224),
            color_mode="rgb",
            shuffle=True),
    output_types=(tf.float32, tf.float32),
    output_shapes=([None,224,224,3],[None,5])
)
```

`tf.data` + `ImageDataGenerator`

- Initialize `ImageDataGenerator` with the augmentations.
- Wrap the generator with `tf.data`

```
model = get_me_a_good_model()
model.fit(train_set,
          steps_per_epoch=train_data//32,
          epochs=5)
```

`tf.data` is (quite) *fast*

- It drastically speeds up the data loading time.
  - Here's a comparison on the **FashionMNIST** dataset:
    - Data loading with `ImageDataGenerator`:

```
1000 batches: 4.16782808303833 s
61422.87899 Images/s
```

    - Data loading with `tf.data`:

```
1000 batches: 0.621355056762695 3 s
412002.76269 Images/s
```

`tf.data` is (quite) *fast*

- It drastically speeds up the data loading time.
- Fast data loading indeed speeds up model training.
  - `ImageDataGenerator` on the **Flowers dataset:**

```
114/114 [==============================] - 144s 1s/step - loss: 5.5306 - accuracy: 0.5962
Epoch 2/5
114/114 [==============================] - 135s 1s/step - loss: 3.3431 - accuracy: 0.7526
Epoch 3/5
114/114 [==============================] - 135s 1s/step - loss: 2.7142 - accuracy: 0.7974
Epoch 4/5
114/114 [==============================] - 135s 1s/step - loss: 2.4073 - accuracy: 0.8120
Epoch 5/5
114/114 [==============================] - 135s 1s/step - loss: 2.0779 - accuracy: 0.8378
It took 685.5545630455017 seconds
```

  - `tf.data` on the **Flowers dataset**:

```
Epoch 1/5
Found 3670 images belonging to 5 classes.
114/114 [==============================] - 80s 704ms/step - loss: 5.2687 - accuracy: 0.6757
Epoch 2/5
114/114 [==============================] - 82s 715ms/step - loss: 0.9821 - accuracy: 0.7883
Epoch 3/5
114/114 [==============================] - 79s 695ms/step - loss: 0.6616 - accuracy: 0.8219
Epoch 4/5
114/114 [==============================] - 79s 695ms/step - loss: 0.4871 - accuracy: 0.8535
Epoch 5/5
114/114 [==============================] - 80s 699ms/step - loss: 0.3722 - accuracy: 0.8821
It took 399.8591330051422 seconds
```