Defining neural networks with Keras

INTRODUCTION TO TENSORFLOW IN PYTHON

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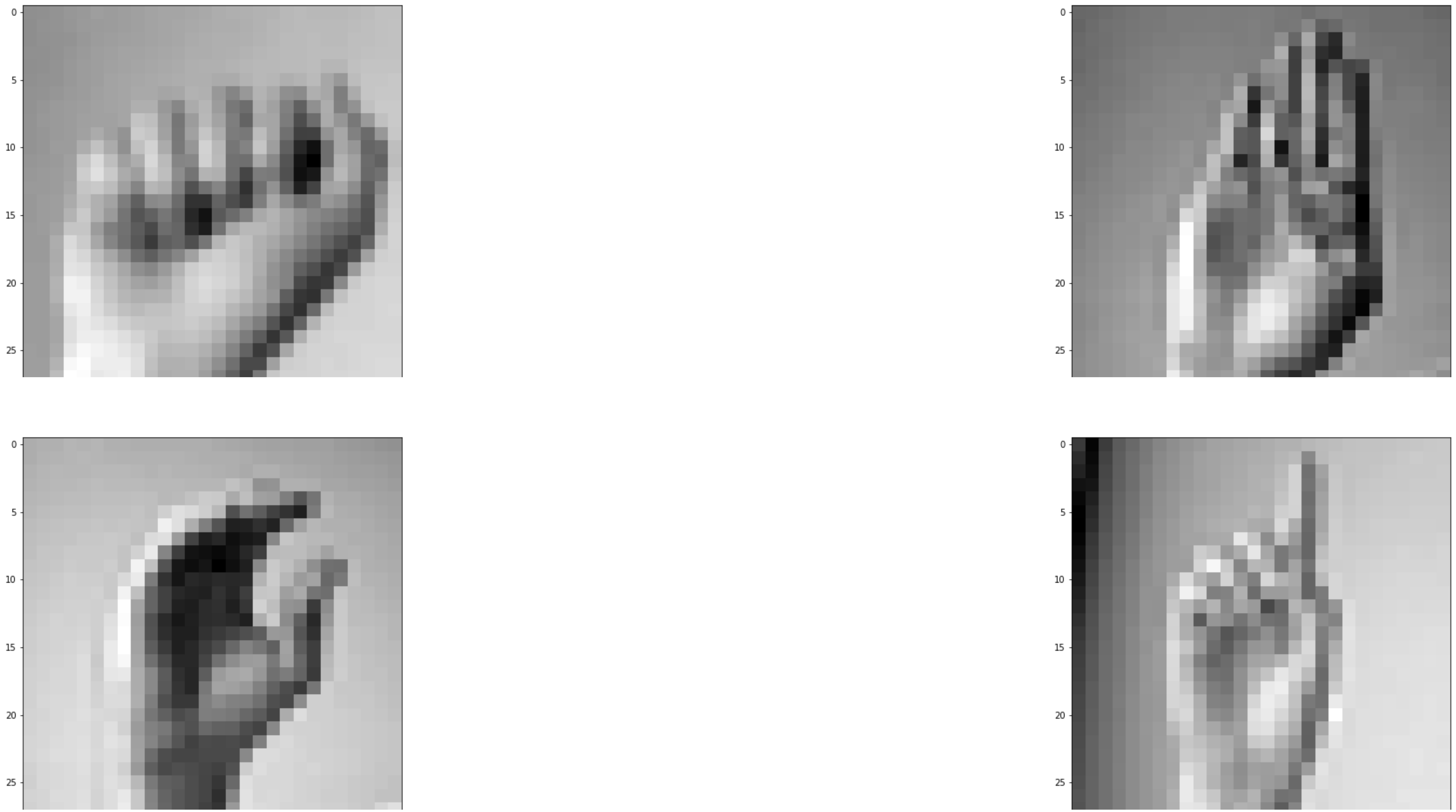
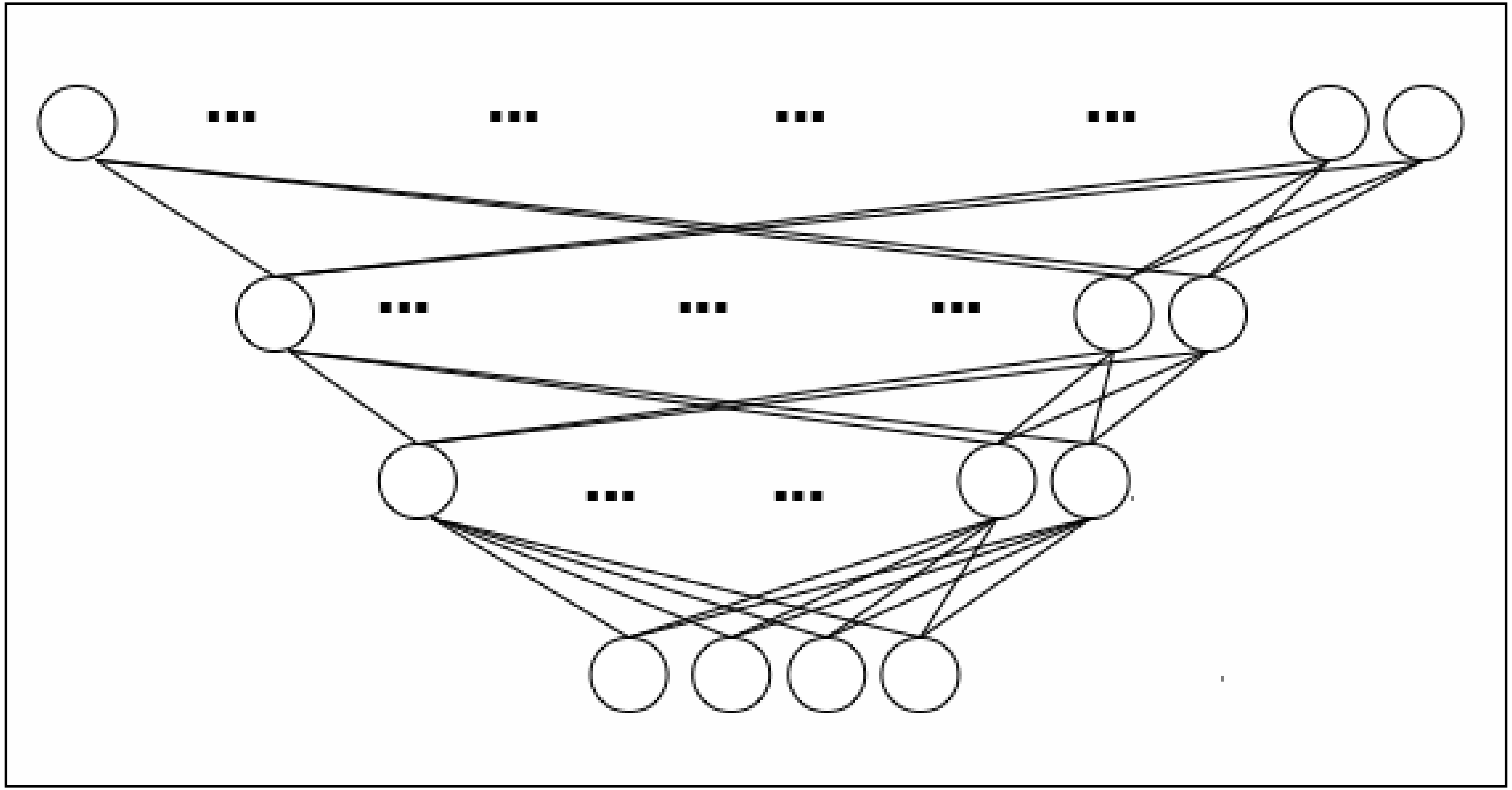
Classifying sign language letters



The sequential API



The sequential API

- Input layer
- Hidden layers
- Output layer
- Ordered in sequence

Building a sequential model

```python
# Import tensorflow
from tensorflow import keras


# Define a sequential model
model = keras.Sequential()
```

```python
# Define first hidden layer
model.add(keras.layers.Dense(16, activation='relu', input_shape=(28*28,)))
```

Building a sequential model

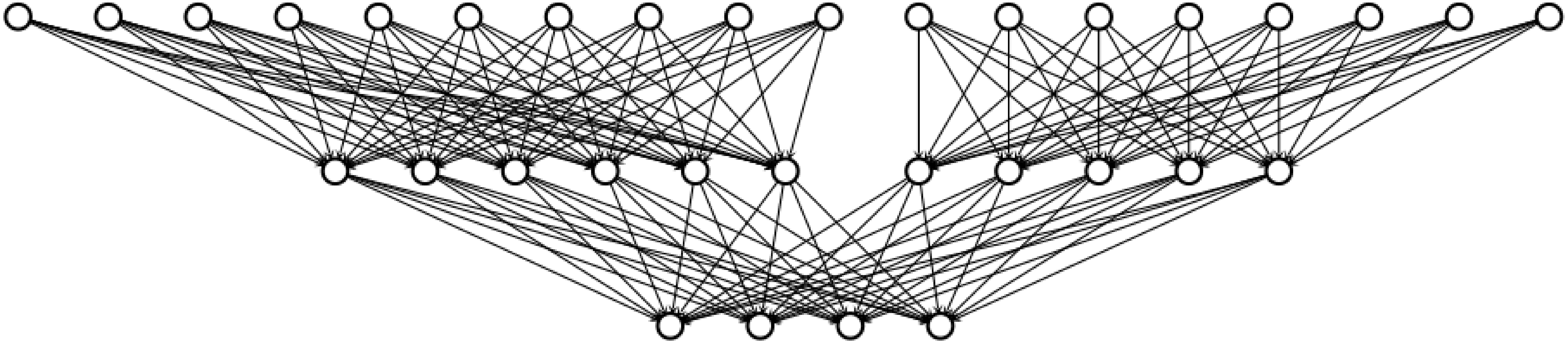
```
# Define second hidden layer
model.add(keras.layers.Dense(8, activation='relu'))
```

```
# Define output layer
model.add(keras.layers.Dense(4, activation='softmax'))
```

```
# Compile the model
model.compile('adam', loss='categorical_crossentropy')
```

```
# Summarize the model
print(model.summary())
```

The functional API



Using the functional API

```
# Import tensorflow
import tensorflow as tf

# Define model 1 input layer shape
model1_inputs = tf.keras.Input(shape=(28*28,))

# Define model 2 input layer shape
model2_inputs = tf.keras.Input(shape=(10,))
```

```
# Define layer 1 for model 1
model1_layer1 = tf.keras.layers.Dense(12, activation='relu')(model1_inputs)

# Define layer 2 for model 1
model1_layer2 = tf.keras.layers.Dense(4, activation='softmax')(model1_layer1)
```

Using the functional API

```
# Define layer 1 for model 2
model2_layer1 = tf.keras.layers.Dense(8, activation='relu')(model2_inputs)

# Define layer 2 for model 2
model2_layer2 = tf.keras.layers.Dense(4, activation='softmax')(model2_layer1)
```

```
# Merge model 1 and model 2
merged = tf.keras.layers.add([model1_layer2, model2_layer2])
```

```
# Define a functional model
model = tf.keras.Model(inputs=[model1_inputs, model2_inputs], outputs=merged)

# Compile the model
model.compile('adam', loss='categorical_crossentropy')
```

Let's practice!

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Training and validation with Keras

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Overview of training and evaluation

1. Load and clean data
2. Define model
3. Train and validate model
4. Evaluate model

How to train a model

```python
# Import tensorflow
import tensorflow as tf

# Define a sequential model
model = tf.keras.Sequential()
```

```python
# Define the hidden layer
model.add(tf.keras.layers.Dense(16, activation='relu', input_shape=(784,)))
```

```python
# Define the output layer
model.add(tf.keras.layers.Dense(4, activation='softmax'))
```

How to train a model

```
# Compile model
model.compile('adam', loss='categorical_crossentropy')
```

```
# Train model
model.fit(image_features, image_labels)
```

The fit() operation

- Required arguments
  - `features`
  - `labels`
- Many optional arguments
  - `batch_size`
  - `epochs`
  - `validation_split`

Batch size and epochs

Epochs

Batches

Batch	price	sqft_lot	bedrooms
Batch 1	221900.0	5650	3
	538000.0	7242	3
	180000.0		2
	604000.0	5000	4
	510000.0	8080	3
Batch 2	1225000.0	101930	4
	257500.0	6819	3
	291850.0		3
	229500.0	7470	3
	323000.0	6560	3
Batch 3	662500.0	9796	3
	468000.0	6000	2
	310000.0		3
	400000.0	9680	3
	530000.0	4850	5

Batch	price	sqft_lot	bedrooms
Batch 1	221900.0	5650	3
	538000.0	7242	3
	180000.0		2
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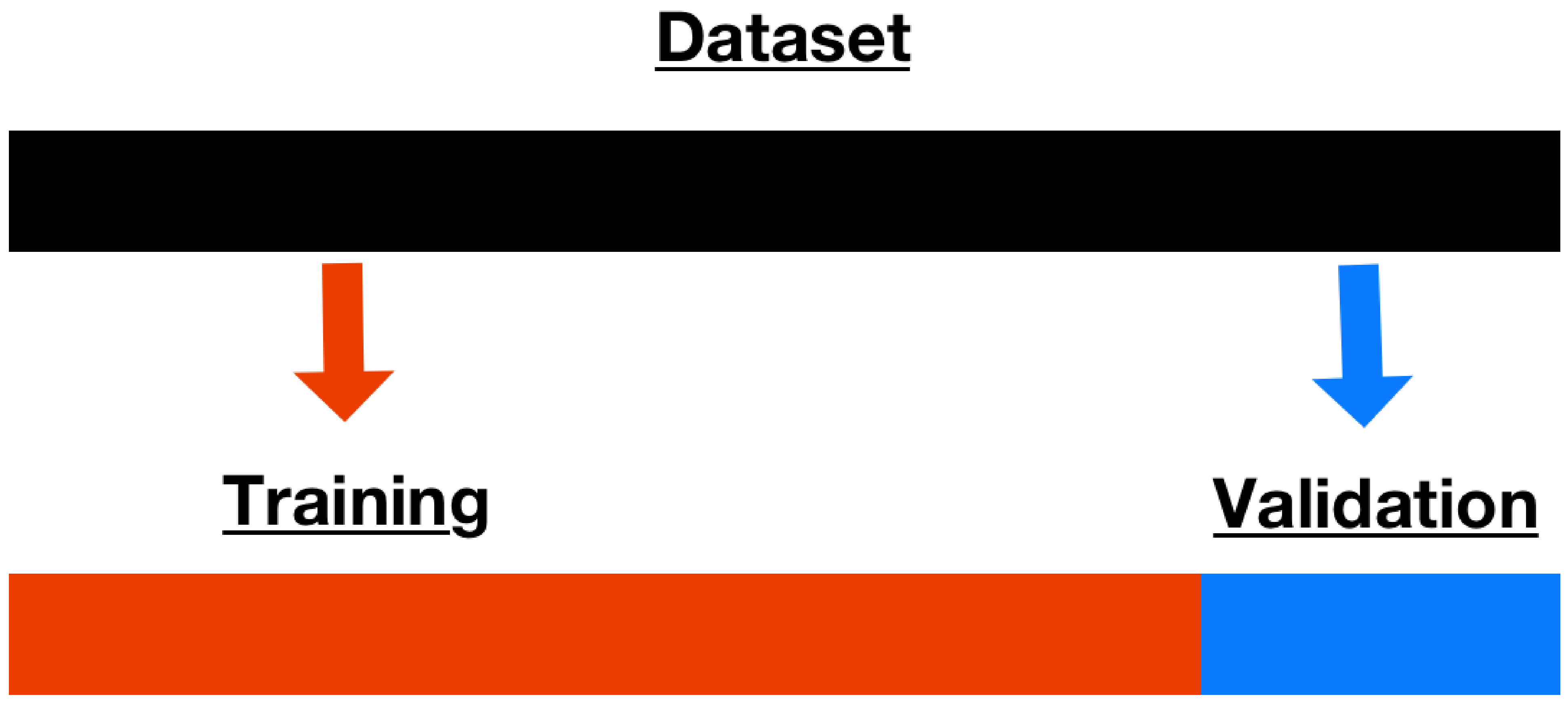
Batch 2	1225000.0	101930	4
	257500.0	6819	3
	291850.0		3
	229500.0	7470	3
	323000.0	6560	3
Batch 3	662500.0	9796	3
	468000.0	6000	2
	310000.0		3
	400000.0	9680	3
	530000.0	4850	5

Performing validation



Performing validation

```
# Train model with validation split
model.fit(features, labels, epochs=10, validation_split=0.20)
```

Performing validation

```
Train on 1599 samples, validate on 400 samples
Epoch 1/10
1599/1599==============================] - 0s 159us/sample - loss: 1.2291 - val_loss: 1.0122
Epoch 2/10
1599/1599==============================] - 0s 60us/sample - loss: 0.8873 - val_loss: 0.7181
Epoch 3/10
1599/1599==============================] - 0s 61us/sample - loss: 0.6476 - val_loss: 0.5414
Epoch 4/10
1599/1599==============================] - 0s 58us/sample - loss: 0.4974 - val_loss: 0.4254
Epoch 5/10
1599/1599==============================] - 0s 57us/sample - loss: 0.3958 - val_loss: 0.3544
Epoch 6/10
1599/1599==============================] - 0s 62us/sample - loss: 0.3222 - val_loss: 0.2936
Epoch 7/10
1599/1599==============================] - 0s 58us/sample - loss: 0.2730 - val_loss: 0.2555
Epoch 8/10
1599/1599==============================] - 0s 56us/sample - loss: 0.2320 - val_loss: 0.2131
Epoch 9/10
1599/1599==============================] - 0s 59us/sample - loss: 0.1957 - val_loss: 0.1843
Epoch 10/10
1599/1599==============================] - 0s 55us/sample - loss: 0.1663 - val_loss: 0.1657
```

Changing the metric

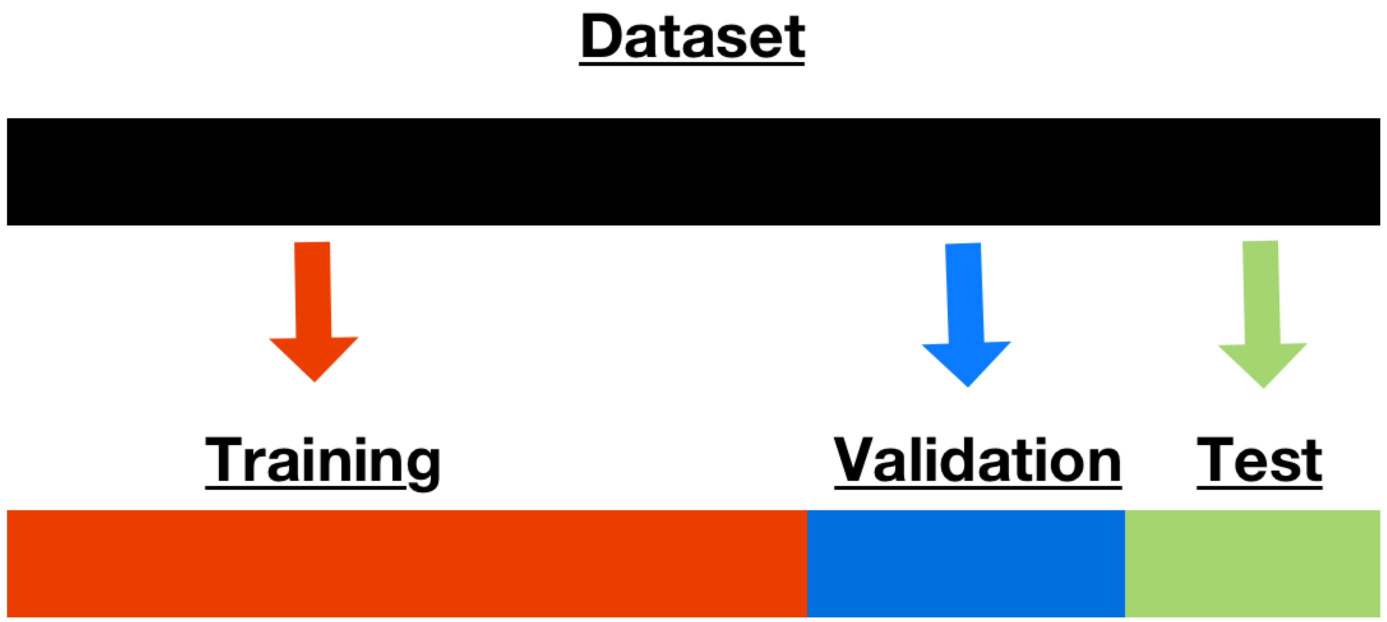
```
# Recomile the model with the accuracy metric
model.compile('adam', loss='categorical_crossentropy', metrics=['accuracy'])
```

```
# Train model with validation split
model.fit(features, labels, epochs=10, validation_split=0.20)
```

Changing the metric

```
Train on 1599 samples, validate on 400 samples
Epoch 1/10
1599/1599==============================] - 0s 174us/sample - loss: 1.2956 - acc: 0.4196 - val_loss: 1.1189 - val_acc: 0.5075
Epoch 2/10
1599/1599==============================] - 0s 59us/sample - loss: 0.9356 - acc: 0.7949 - val_loss: 0.7843 - val_acc: 0.8225
Epoch 3/10
1599/1599==============================] - 0s 59us/sample - loss: 0.6657 - acc: 0.9037 - val_loss: 0.5588 - val_acc: 0.8925
Epoch 4/10
1599/1599==============================] - 0s 58us/sample - loss: 0.4898 - acc: 0.9206 - val_loss: 0.4220 - val_acc: 0.9175
Epoch 5/10
1599/1599==============================] - 0s 59us/sample - loss: 0.3734 - acc: 0.9681 - val_loss: 0.3319 - val_acc: 0.9825
Epoch 6/10
1599/1599==============================] - 0s 61us/sample - loss: 0.2975 - acc: 0.9762 - val_loss: 0.2907 - val_acc: 0.9075
Epoch 7/10
1599/1599==============================] - 0s 60us/sample - loss: 0.2414 - acc: 0.9731 - val_loss: 0.2276 - val_acc: 0.9550
Epoch 8/10
1599/1599==============================] - 0s 61us/sample - loss: 0.1912 - acc: 0.9887 - val_loss: 0.2026 - val_acc: 0.9525
Epoch 9/10
1599/1599==============================] - 0s 59us/sample - loss: 0.1649 - acc: 0.9862 - val_loss: 0.1684 - val_acc: 0.9675
Epoch 10/10
1599/1599==============================] - 0s 58us/sample - loss: 0.1390 - acc: 0.9912 - val_loss: 0.1374 - val_acc: 0.9825
```

The evaluation() operation




```
# Evaluate the test set
model.evaluate(test)
```

Let's practice!

INTRODUCTION TO TENSORFLOW IN PYTHON

Training models with the Estimators API

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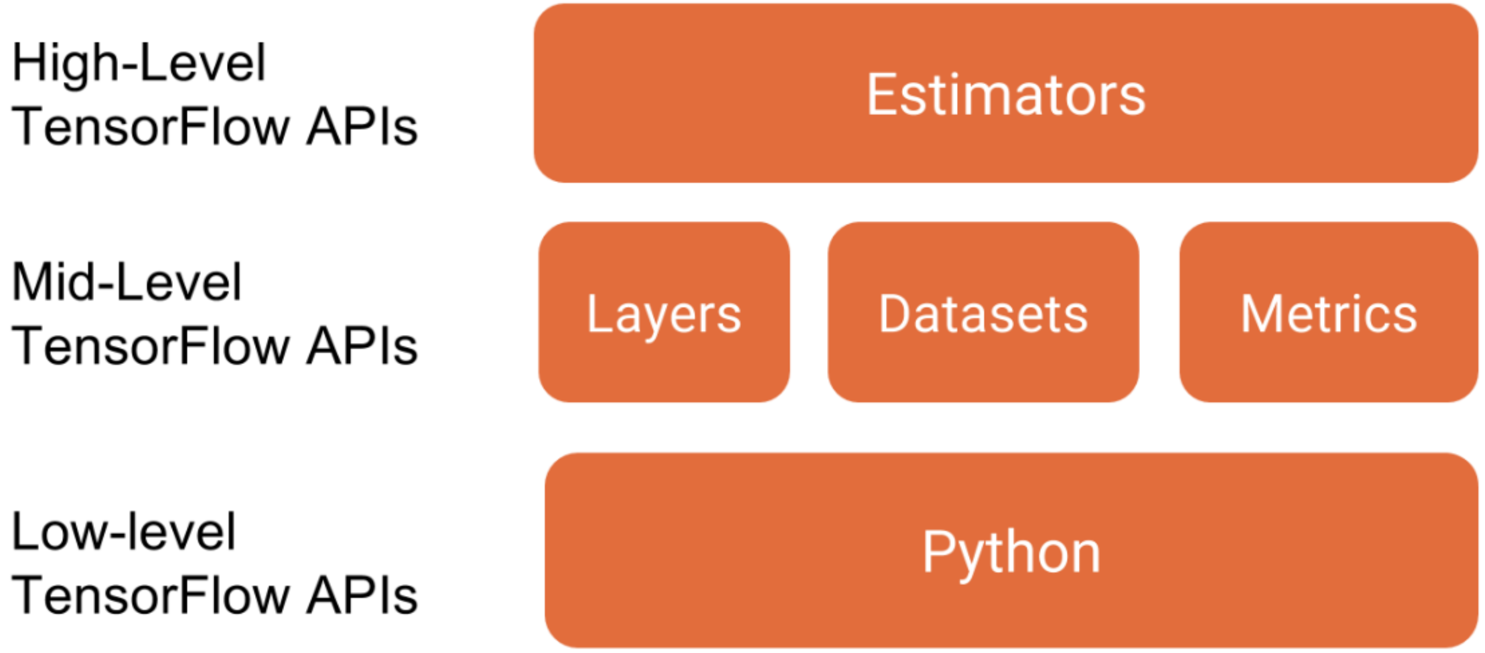
What is the Estimators API?

- High level submodule
- Less flexible
- Enforces best practices
- Faster deployment
- Many premade models



[1] Image taken from https://www.tensorflow.org/guide/premade_estimators

Model specification and training

1. Define feature columns
2. Load and transform data
3. Define an estimator
4. Apply train operation

Defining feature columns

```
# Import tensorflow under its standard alias
import tensorflow as tf

# Define a numeric feature column
size = tf.feature_column.numeric_column("size")
```

```
# Define a categorical feature column
rooms = tf.feature_column.categorical_column_with_vocabulary_list("rooms",\
["1", "2", "3", "4", "5"])
```

Defining feature columns

```
# Create feature column list
features_list = [size, rooms]
```

```
# Define a matrix feature column
features_list = [tf.feature_column.numeric_column('image', shape=(784,))]
```

Loading and transforming data

```
# Define input data function
def input_fn():
    # Define feature dictionary
    features = {"size": [1340, 1690, 2720], "rooms": [1, 3, 4]}
    # Define labels
    labels = [221900, 538000, 180000]
    return features, labels
```

Define and train a regression estimator

```
# Define a deep neural network regression
model0 = tf.estimator.DNNRegressor(feature_columns=feature_list,\
    hidden_units=[10, 6, 6, 3])

# Train the regression model
model0.train(input_fn, steps=20)
```

Define and train a deep neural network

```
# Define a deep neural network classifier
model1 = tf.estimator.DNNClassifier(feature_columns=feature_list,\
    hidden_units=[32, 16, 8], n_classes=4)

# Train the classifier
model1.train(input_fn, steps=20)
```

- https://www.tensorflow.org/guide/estimators

Let's practice!

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Congratulations!

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What you learned

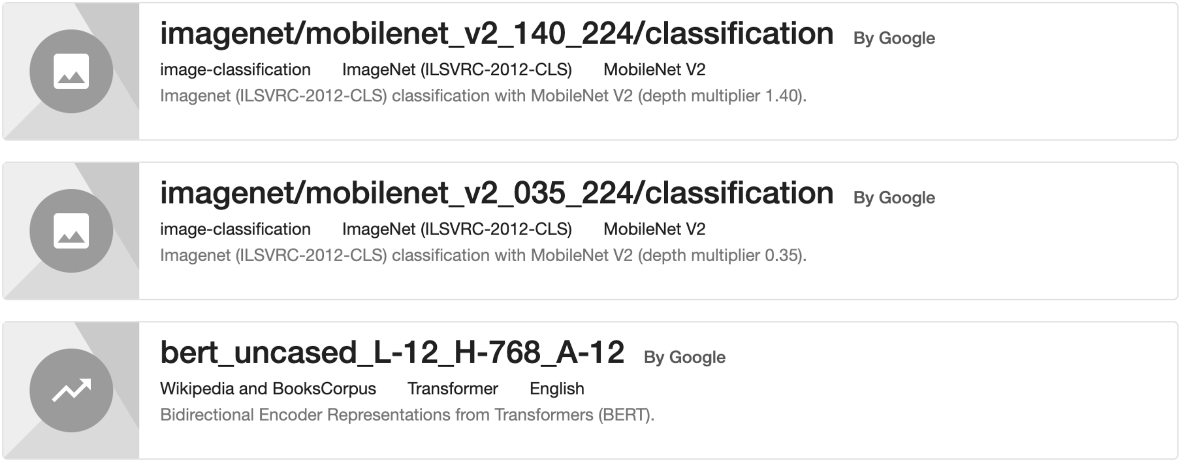
- **Chapter 1**
  - Low-level, basic, and advanced operations
  - Graph-based computation
  - Gradient computation and optimization
- **Chapter 2**
  - Data loading and transformation
  - Predefined and custom loss functions
  - Linear models and batch training

What you learned

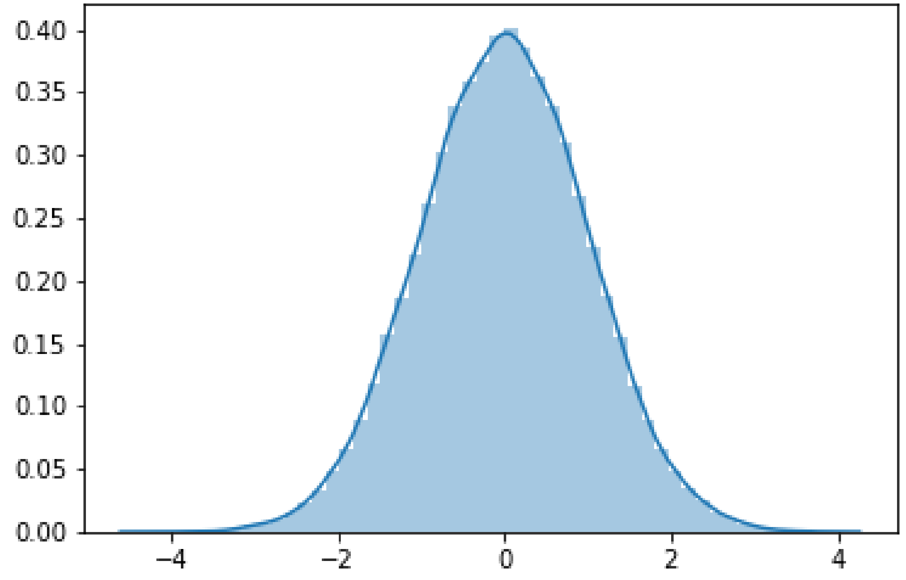
- **Chapter 3**
  - Dense neural network layers
  - Activation functions
  - Optimization algorithms
  - Training neural networks
- **Chapter 4**
  - Neural networks in Keras
  - Training and validation
  - The Estimators API

TensorFlow extensions

- **TensorFlow Hub**
  - Pretrained models
  - Transfer learning



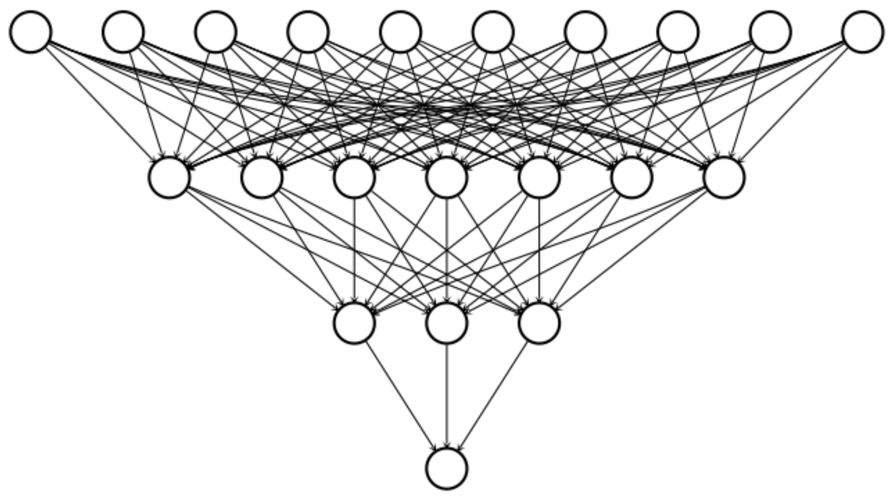
- **TensorFlow Probability**
  - More statistical distributions
  - Trainable distributions
  - Extended set of optimizers

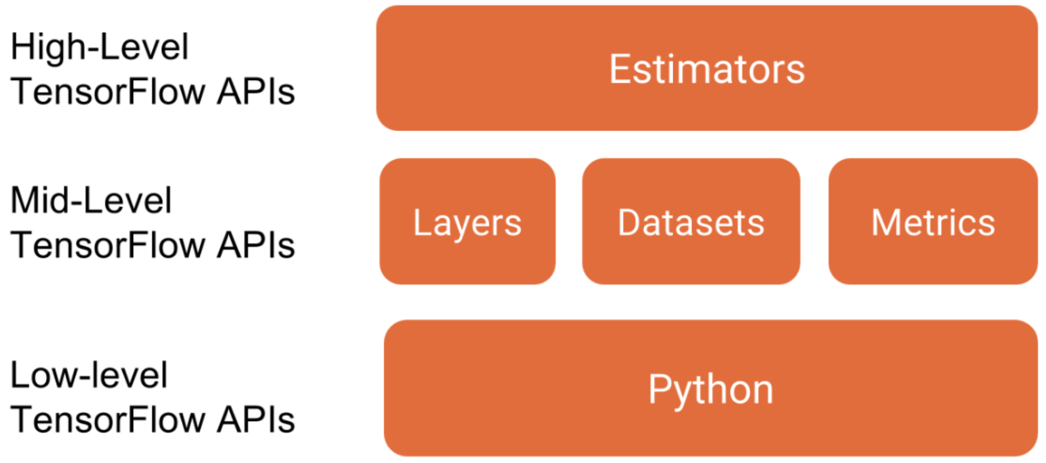


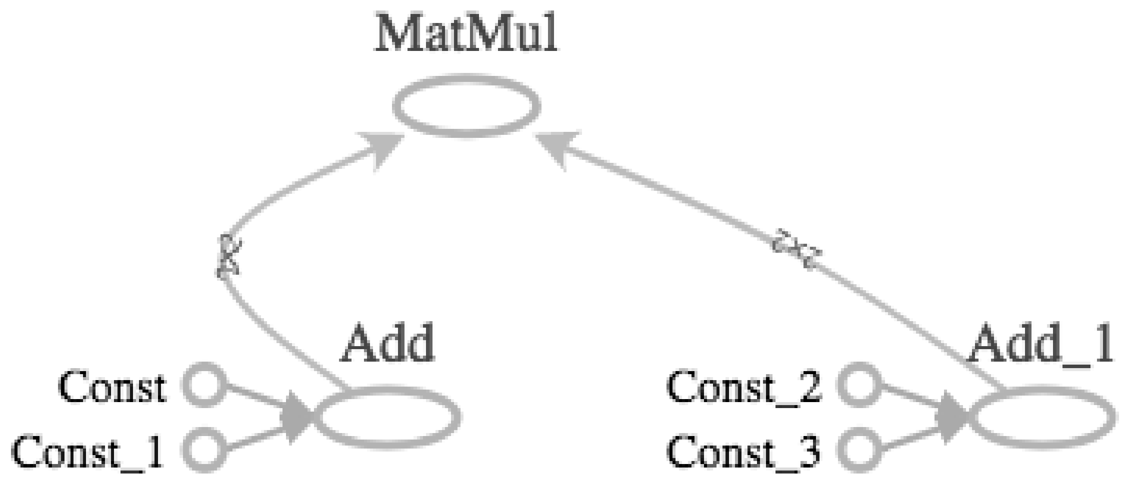
[1] Screenshot from https://tfhub.dev.

TensorFlow 2.0

- TensorFlow 2.0
  - `eager_execution()`
  - Tighter `keras` integration
  - `Estimators`







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Congratulations!

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