Basic type of creating custom layer using the "lambda" layer.

```
tf.keras.layers.Lambda(lambda x: tf.abs(x))
```

← This best suited for simple and easy-to-use ones.

```
tf.keras.layers.Lambda(lambda x: tf.abs(x))
```

lambda value

mapped to this function

```
tf.keras.layers.Lambda(lambda x: tf.abs(x))
```

```
model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(input_shape=(28, 28)),
  tf.keras.layers.Dense(128, activation='relu'),
  tf.keras.layers.Dense(10, activation='softmax')
])
```

only positive values flow

zeros out all the negative values.

```
model = tf.keras.models.Sequential([
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  tf.keras.layers.Dense(128, activation='relu'), ✓
  tf.keras.layers.Dense(10, activation='softmax')
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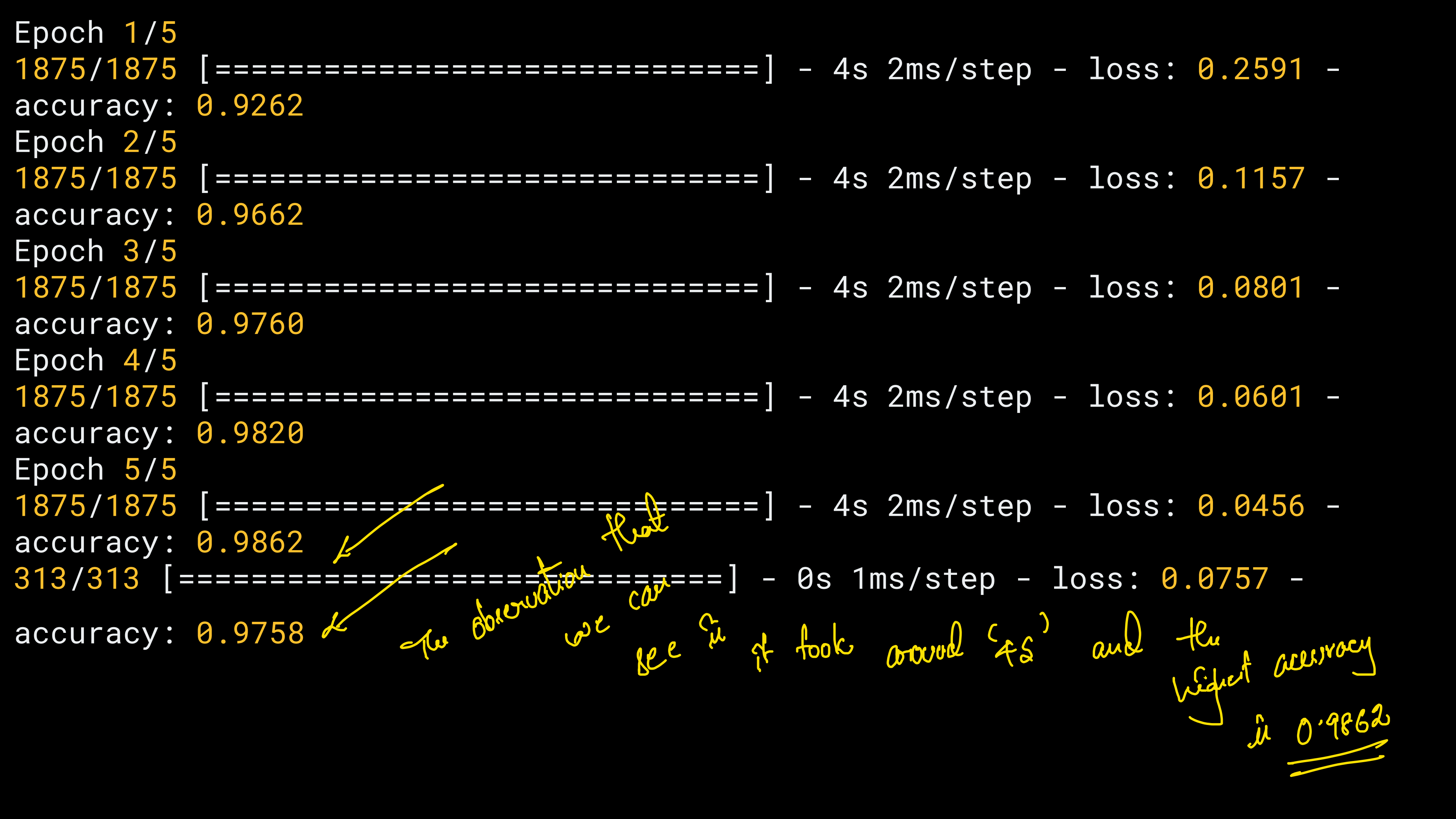
  tf.keras.layers.Dense(128, activation='relu'),
  tf.keras.layers.Dense(10, activation='softmax')
])
```

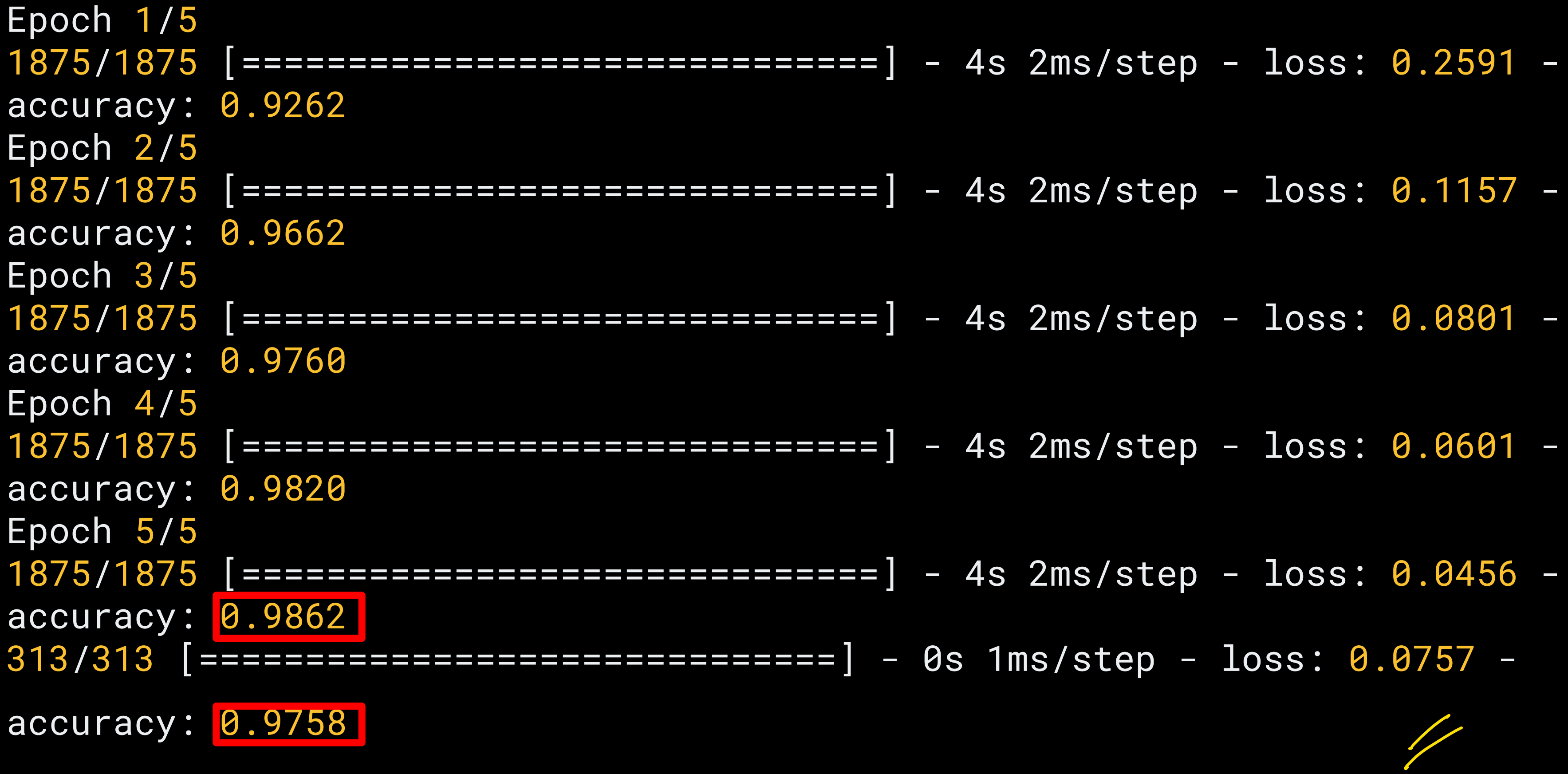
```
if(x>0):
    return x
else:
    return 0
```



```
Epoch 1/5
1875/1875 [==============================] - 4s 2ms/step - loss: 0.2591 -
accuracy: 0.9262
Epoch 2/5
1875/1875 [==============================] - 4s 2ms/step - loss: 0.1157 -
accuracy: 0.9662
Epoch 3/5
1875/1875 [==============================] - 4s 2ms/step - loss: 0.0801 -
accuracy: 0.9760
Epoch 4/5
1875/1875 [==============================] - 4s 2ms/step - loss: 0.0601 -
accuracy: 0.9820
Epoch 5/5
1875/1875 [==============================] - 4s 2ms/step - loss: 0.0456 -
accuracy: 0.9862
313/313 [==============================] - 0s 1ms/step - loss: 0.0757 -

accuracy: 0.9758
```

The observation that we can see is it took around '4s' and the highest accuracy is 0·9862



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1875/1875 [==============================] - 4s 2ms/step - loss: 0.2591 -
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1875/1875 [==============================] - 4s 2ms/step - loss: 0.1157 -
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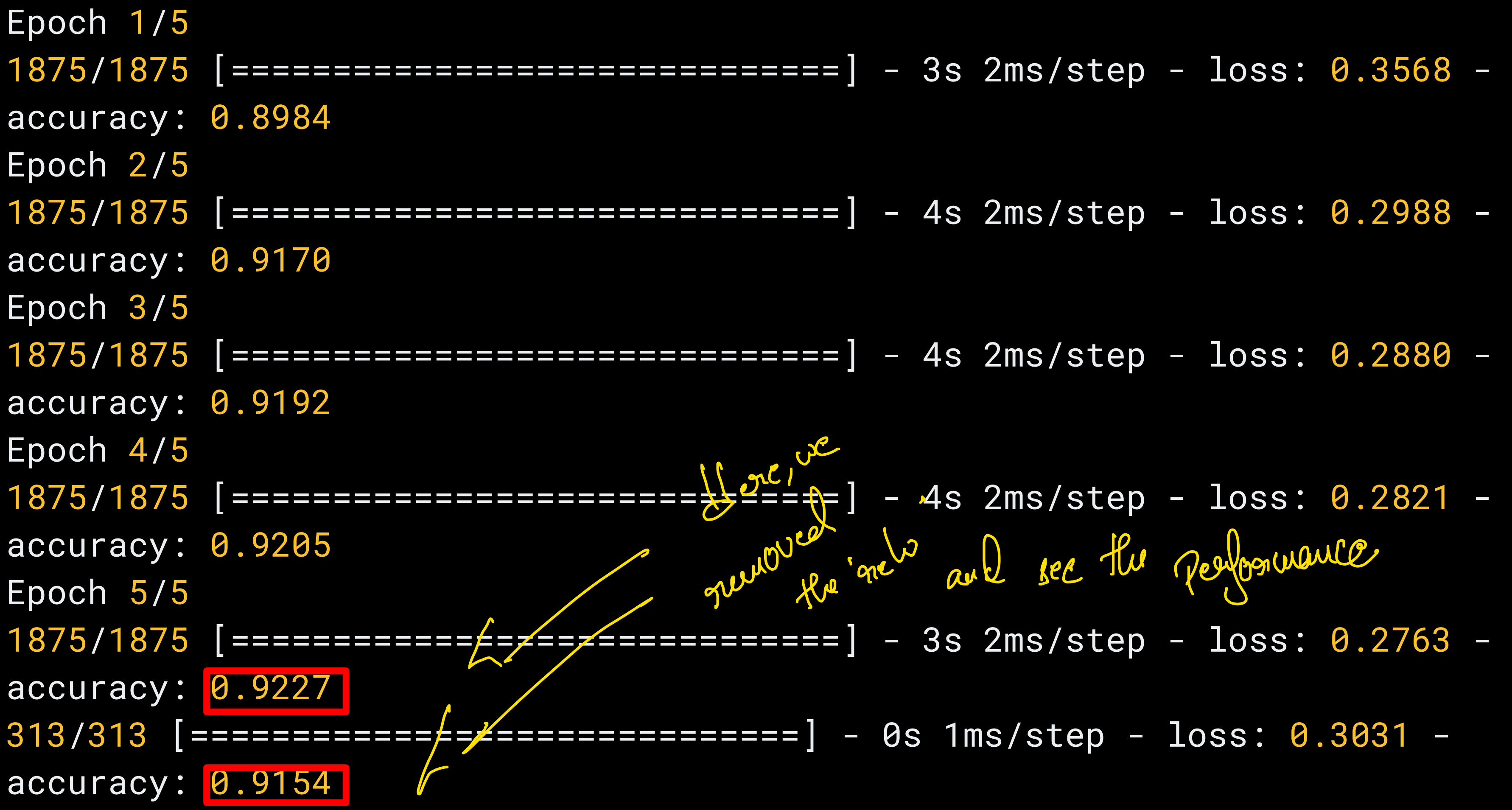
accuracy: 0.9758
```

```
Epoch 1/5
1875/1875 [==============================] - 3s 2ms/step - loss: 0.3568 -
accuracy: 0.8984
Epoch 2/5
1875/1875 [==============================] - 4s 2ms/step - loss: 0.2988 -
accuracy: 0.9170
Epoch 3/5
1875/1875 [==============================] - 4s 2ms/step - loss: 0.2880 -
accuracy: 0.9192
Epoch 4/5
1875/1875 [==============================] - 4s 2ms/step - loss: 0.2821 -
accuracy: 0.9205
Epoch 5/5
1875/1875 [==============================] - 3s 2ms/step - loss: 0.2763 -
accuracy: 0.9227
313/313 [==============================] - 0s 1ms/step - loss: 0.3031 -
accuracy: 0.9154
```



```
Epoch 1/5
1875/1875 [==============================] - 3s 2ms/step - loss: 0.3568 -
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Epoch 2/5
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accuracy: 0.9170
Epoch 3/5
1875/1875 [==============================] - 4s 2ms/step - loss: 0.2880 -
accuracy: 0.9192
Epoch 4/5
1875/1875 [==============================] - 4s 2ms/step - loss: 0.2821 -
accuracy: 0.9205
Epoch 5/5
1875/1875 [==============================] - 3s 2ms/step - loss: 0.2763 -
accuracy: 0.9227
313/313 [==============================] - 0s 1ms/step - loss: 0.3031 -
accuracy: 0.9154
```

Here, we removed the 'relu' and see the Performance

```
model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(input_shape=(28, 28)),
  tf.keras.layers.Dense(128),
  tf.keras.layers.Lambda(lambda x: tf.abs(x)),
  tf.keras.layers.Dense(10, activation='softmax')
])
```

← now, we added the custom layer using lambda function and removed the 'relu' function

✓ ✓

```
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  tf.keras.layers.Flatten(input_shape=(28, 28)),
  tf.keras.layers.Dense(128),
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  tf.keras.layers.Dense(10, activation='softmax')
])
```

```
Epoch 1/5
1875/1875 [==============================] - 4s 2ms/step - loss: 0.2229 -
accuracy: 0.9377
Epoch 2/5
1875/1875 [==============================] - 3s 2ms/step - loss: 0.0908 -
accuracy: 0.9734
Epoch 3/5
1875/1875 [==============================] - 3s 2ms/step - loss: 0.0636 -
accuracy: 0.9807
Epoch 4/5
1875/1875 [==============================] - 4s 2ms/step - loss: 0.0471 -
accuracy: 0.9853
Epoch 5/5
1875/1875 [==============================] - 4s 2ms/step - loss: 0.0396 -
accuracy: 0.9875
313/313 [==============================] - 0s 1ms/step - loss: 0.0840 -
accuracy: 0.9751
```

The performance
we see increased

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Epoch 5/5
1875/1875 [==============================] - 4s 2ms/step - loss: 0.0396 -
accuracy: 0.9875
313/313 [==============================] - 0s 1ms/step - loss: 0.0840 -

accuracy: 0.9751
```

end at the same time

we see less time than the 'gelo'

```
def my_relu(x):
  return K.maximum(0.0, x)

model = tf.keras.models.Sequential([
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  tf.keras.layers.Dense(128),
  tf.keras.layers.Lambda(my_relu),
  tf.keras.layers.Dense(10, activation='softmax')
])
```

calling the function instead of Lambda approach

```
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```
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  tf.keras.layers.Lambda(my_relu),
  tf.keras.layers.Dense(10, activation='softmax')
])
```

```
def my_relu(x):
  return K.maximum(0.5, x)

model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(input_shape=(28, 28)),
  tf.keras.layers.Dense(128),
  tf.keras.layers.Lambda(my_relu),
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])
```

Some commonly used layers

Convolutional

Conv1D/Conv2D/Conv3D

SeparableConv2D

DepthwiseConv2D

Recurrent

LSTM

GRU

Pooling

MaxPooling2D

AveragePooling2D

GlobalAveragePooling2D

Merge

Add

Subtract

Multiply

Activations (Advanced)

LeakyReLU

PReLU

ELU

Core

Activation

Lambda

Input

Dense

Dropout

BatchNormalization

Some commonly used layers

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Activations (Advanced)

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PReLU

ELU

Core

Activation

Lambda

Input

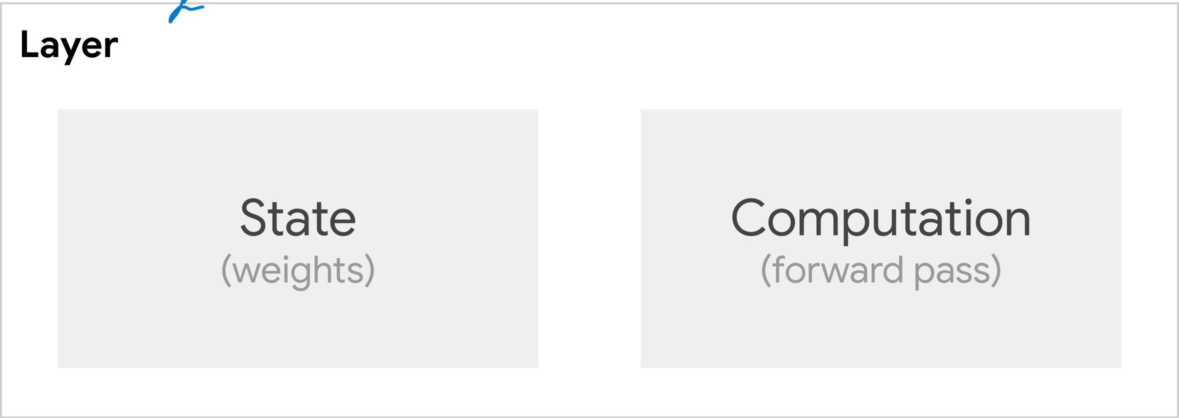
Dense

Dropout

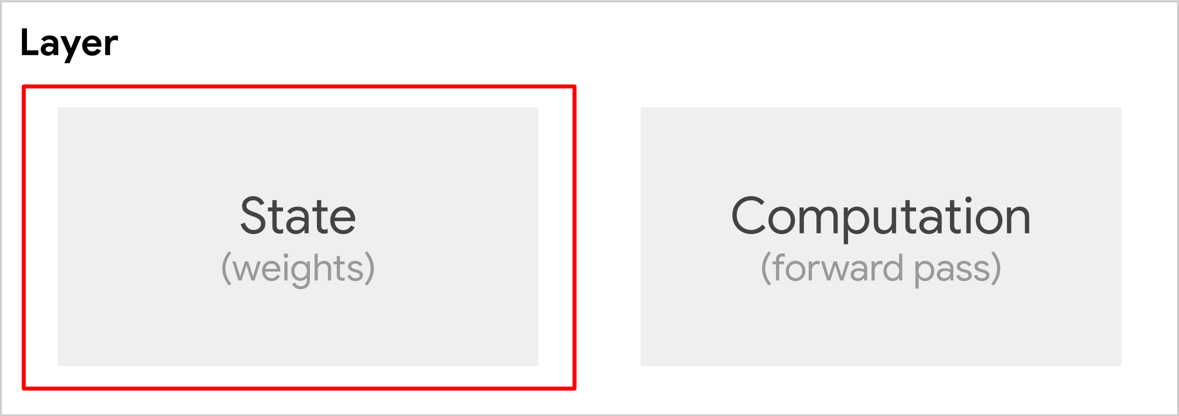
BatchNormalization

What is a Layer?

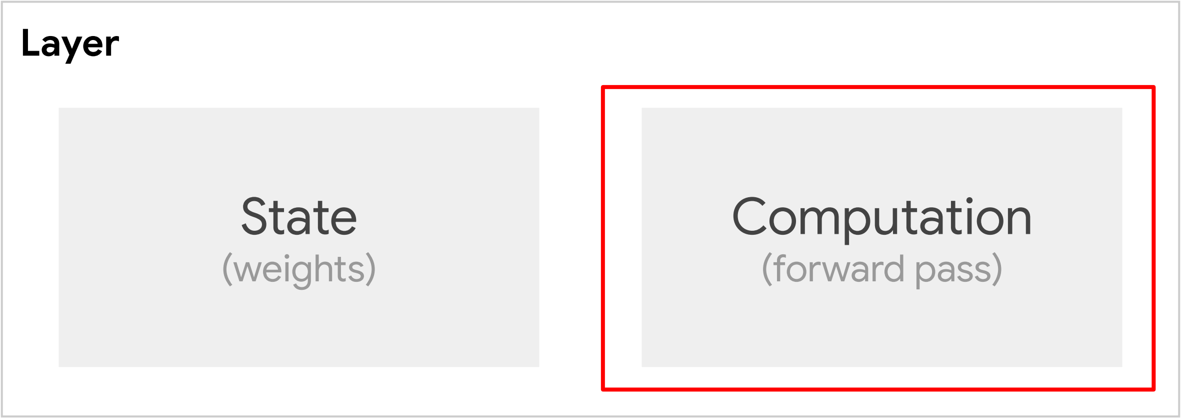
class that captures parameters that encapsulate state and computation to achieve layer purpose in neural network



What is a Layer?



What is a Layer?



Layer

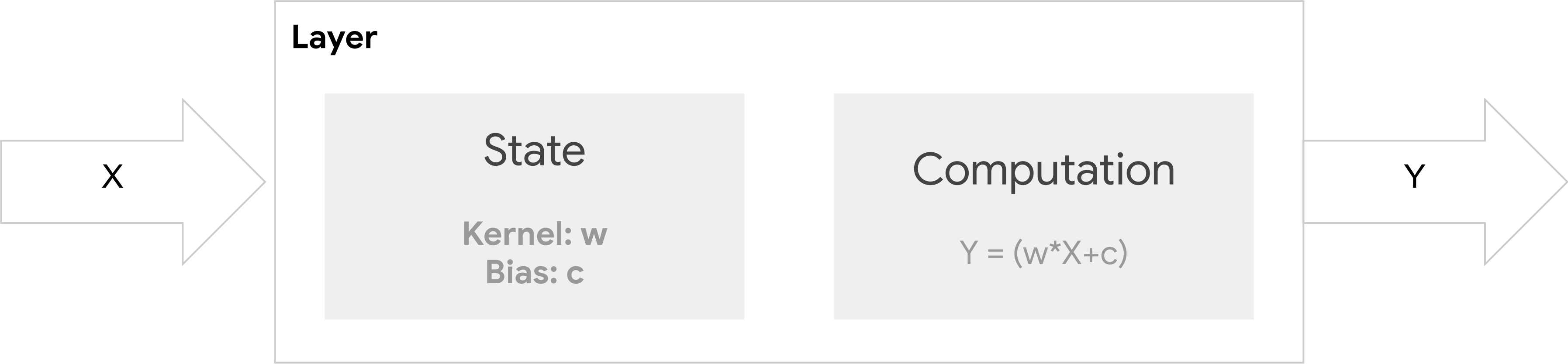
State

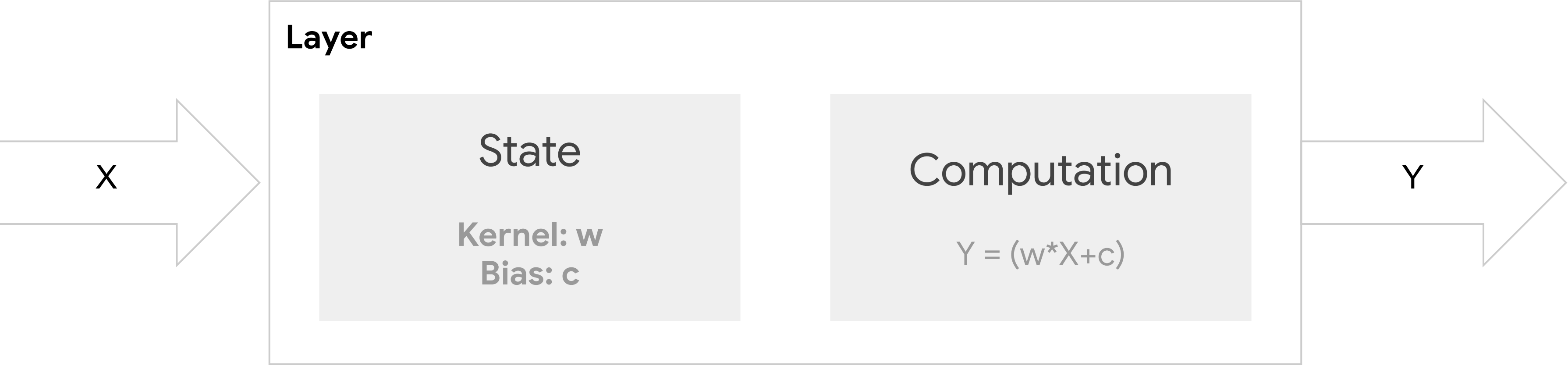
(weights)

Computation

(forward pass)

Simple Dense Layer





X

Layer

State

Kernel: w
Bias: c

Computation

Y = (w*X+c)

Y

```python
class SimpleDense(Layer):

  def __init__(self, units=32):
      super(SimpleDense, self).__init__()
      self.units = units

  def build(self, input_shape):  # Create the state of the layer (weights)
    w_init = tf.random_normal_initializer()
    self.w = tf.Variable(name="kernel",
        initial_value=w_init(shape=(input_shape[-1], self.units), dtype='float32'),
        trainable=True)

    b_init = tf.zeros_initializer()
    self.b = tf.Variable(name="bias",
        initial_value=b_init(shape=(self.units,), dtype='float32'),
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  def call(self, inputs):  # Defines the computation from inputs to outputs
      return tf.matmul(inputs, self.w) + self.b
```

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we are basically inheriting the properties of tensorflow layer class.

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```

Inheriting the initialization from the base class

Store user parameters

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within the build we initialize the "state"

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```

```
my_dense = SimpleDense(units=1)
x = tf.ones((1, 1))
y = my_dense(x)
print(my_dense.variables)
```

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print(my_dense.variables)
```

```
[<tf.Variable 'simple_dense_7/kernel:0' shape=(1, 1)
dtype=float32, numpy=array([[0.03688493]], dtype=float32)>,

<tf.Variable 'simple_dense_7/bias:0' shape=(1,)
dtype=float32, numpy=array([0.], dtype=float32)>]
```

```python
my_dense = SimpleDense(units=1)
x = tf.ones((1, 1))
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```

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[<tf.Variable 'simple_dense_7/kernel:0' shape=(1, 1)
dtype=float32, numpy=array([[0.03688493]], dtype=float32)>,

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dtype=float32, numpy=array([[0.03688493]], dtype=float32)>,

<tf.Variable 'simple_dense_7/bias:0' shape=(1,)
dtype=float32, numpy=array([0.], dtype=float32)>]
```

```python
import numpy as np

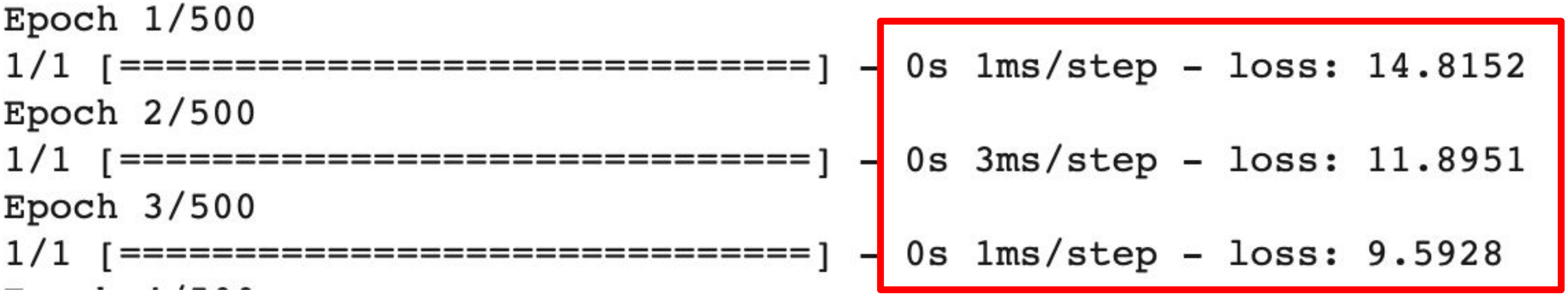
xs = np.array([-1.0,  0.0, 1.0, 2.0, 3.0, 4.0], dtype=float)
ys = np.array([-3.0, -1.0, 1.0, 3.0, 5.0, 7.0], dtype=float)

model = tf.keras.Sequential([SimpleDense(units=1)])
model.compile(optimizer='sgd', loss='mean_squared_error')
model.fit(xs, ys, epochs=500,verbose=0)
print(model.predict([10.0]))
```

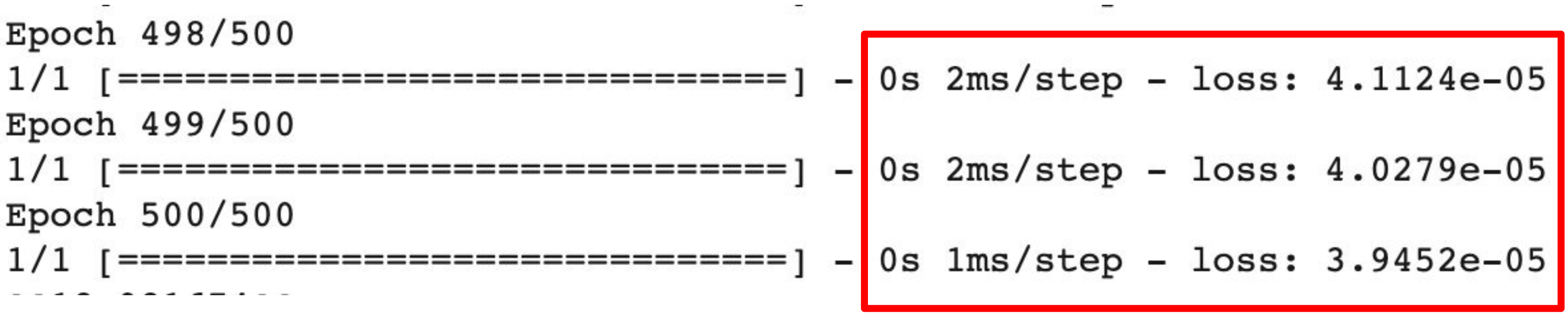
Expected Answer: 19 (y=2x-1)

Actual Answer: 0.36

(W = 0.036, B=0 => Y=.036 * 10 + 0 = 0.36)



```
Epoch 1/500
1/1 [==============================] - 0s 1ms/step - loss: 14.8152
Epoch 2/500
1/1 [==============================] - 0s 3ms/step - loss: 11.8951
Epoch 3/500
1/1 [==============================] - 0s 1ms/step - loss: 9.5928
```



```
Epoch 498/500
1/1 [==============================] - 0s 2ms/step - loss: 4.1124e-05
Epoch 499/500
1/1 [==============================] - 0s 2ms/step - loss: 4.0279e-05
Epoch 500/500
1/1 [==============================] - 0s 1ms/step - loss: 3.9452e-05
```

```
import numpy as np

xs = np.array([-1.0,  0.0, 1.0, 2.0, 3.0, 4.0], dtype=float)
ys = np.array([-3.0, -1.0, 1.0, 3.0, 5.0, 7.0], dtype=float)

model = tf.keras.Sequential([SimpleDense(units=1)])
model.compile(optimizer='sgd', loss='mean_squared_error')
model.fit(xs, ys, epochs=500,verbose=0)
print(model.predict([10.0]))
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```
[[18.981468]]
```

```
[<tf.Variable
'sequential_15/simple_dense_19/kernel:0' shape=(1, 1)
dtype=float32, numpy=array([[1.9972587]],
dtype=float32)>, <tf.Variable
'sequential_15/simple_dense_19/bias:0' shape=(1,)
dtype=float32, numpy=array([-0.991501],
dtype=float32)>]
```

```python
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),
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we're able specify the activation in this situation

But, what we created earlier doesn't have any option of specifying the activation function

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```
model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(input_shape=(28, 28)),
  SimpleDense(128),
  tf.keras.layers.Lambda(my_relu),
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we done a workaround by coding a lambda layer.

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```python
class SimpleDense(Layer):

  def __init__(self, units=32):
      super(SimpleDense, self).__init__()
      self.units = units

  def build(self, input_shape):  # Create the state of the layer (weights)
    w_init = tf.random_normal_initializer()
    self.w = tf.Variable(name="kernel",
        initial_value=w_init(shape=(input_shape[-1], self.units), dtype='float32'),
        trainable=True)

    b_init = tf.zeros_initializer()
    self.b = tf.Variable(name="bias",
        initial_value=b_init(shape=(self.units,), dtype='float32'),
        trainable=True)

  def call(self, inputs):  # Defines the computation from inputs to outputs
      return tf.matmul(inputs, self.w) + self.b
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class SimpleDense(Layer):

  def __init__(self, units=32, activation=None):
      super(SimpleDense, self).__init__()
      self.units = units
      self.activation = tf.keras.activations.get(activation)


  def call(self, inputs):
      return self.activation(tf.matmul(inputs, self.w) + self.b)
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default is "None"

It can take

this is gonna get the activation function

that is named on the initializer

which this we can perform the activation on our custom create activation function

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