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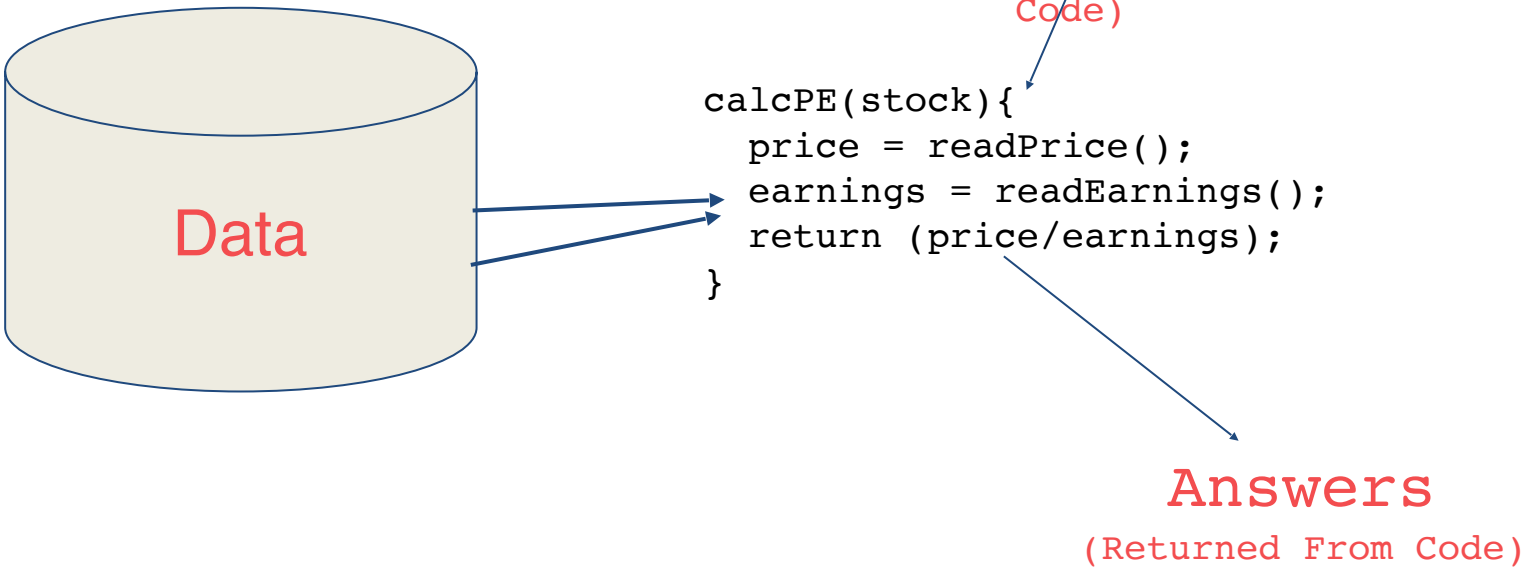
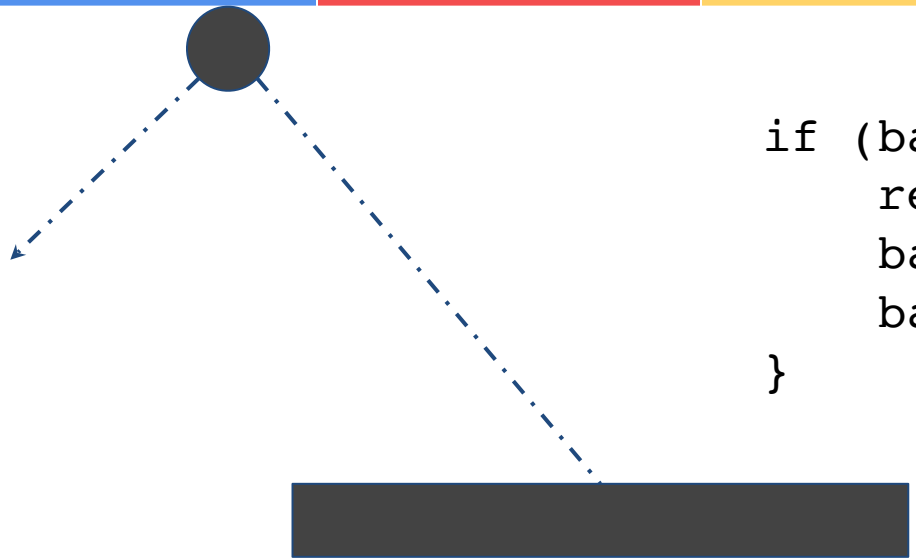
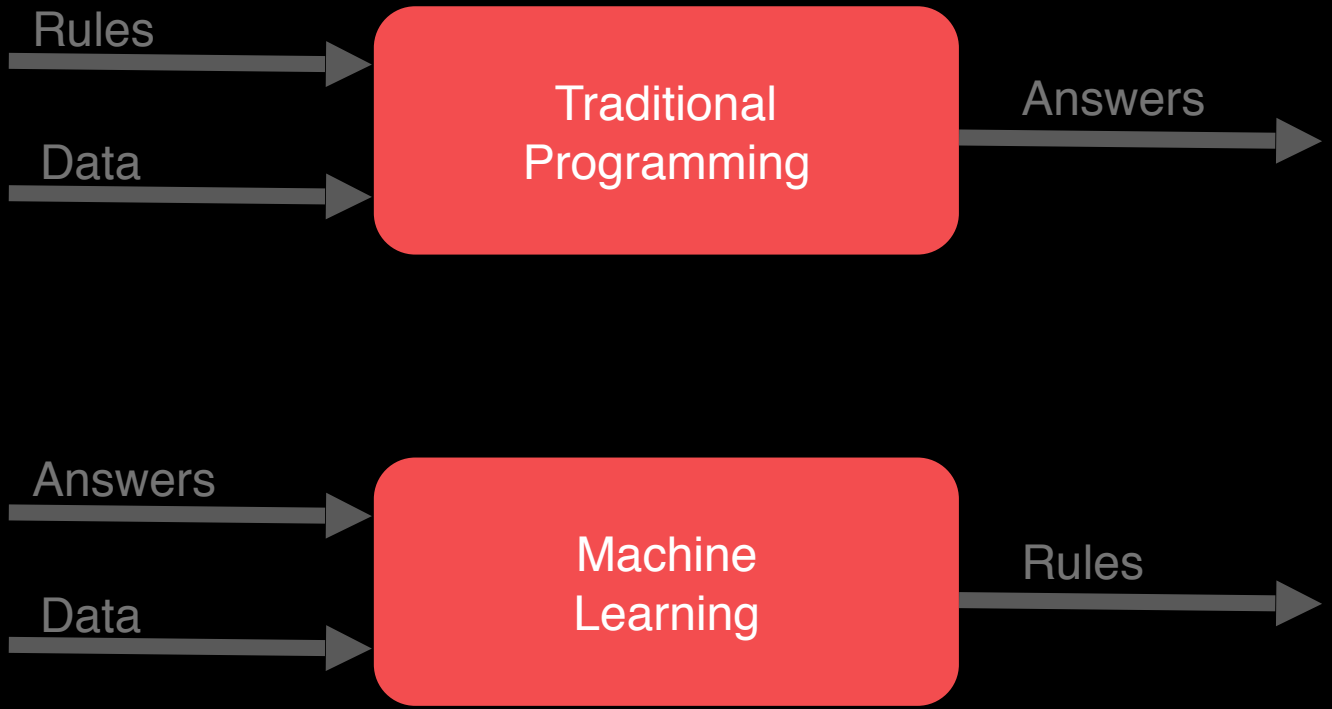

Rules
(Expressed in Code)
Data
calcPE(stock){
price = readPrice();
earnings = readEarnings();
return (price/earnings);
}
Answers
(Returned From Code)



```
if (ball.collide(brick)){
    removeBrick();
    ball.dx=-1*(ball.dx);
    ball.dy=-1*(ball.dy);
}
```


Rules
Data
Traditional Programming
Answers


Rules
Data
Traditional Programming
Answers
Answers
Data
Machine Learning
Rules

Activity Recognition

```
if(speed<4){

status=WALKING;
}
```

Activity Recognition

```
if(speed<4){

status=WALKING;
}
```

```
if(speed<4){

status=WALKING;
} else {

status=RUNNING;
}
```

Activity Recognition

```
if(speed<4){

status=WALKING;
}
```

```
if(speed<4){

status=WALKING;
} else {

status=RUNNING;
}
```

```
if(speed<4){
    status=WALKING;
} else if(speed<12){
    status=RUNNING;
} else {
    status=BIKING;
}
```

Activity Recognition

```
if(speed<4){

status=WALKING;
}
```

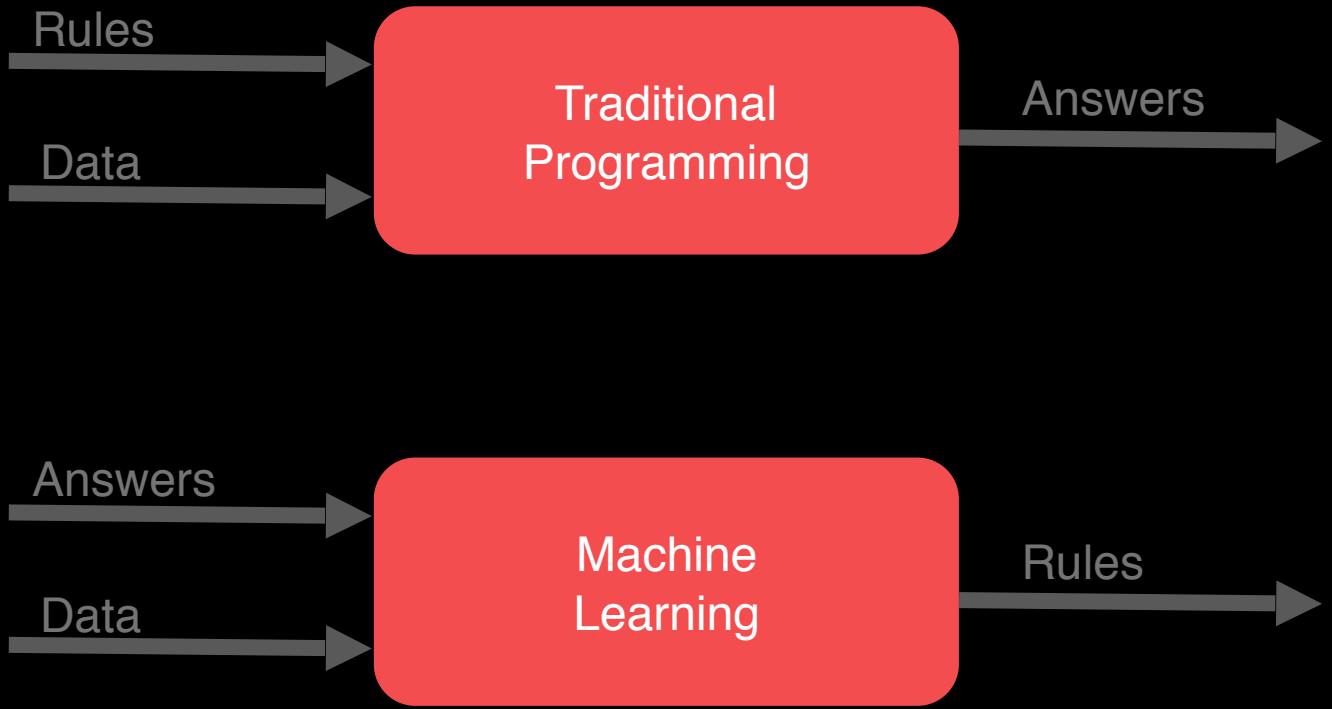
```
if(speed<4){

status=WALKING;
} else {

status=RUNNING;
}
```

```
if(speed<4){
    status=WALKING;
} else if(speed<12){
    status=RUNNING;
} else {
    status=BIKING;
}
```

```
// Oh crap
```


Rules
Data
Traditional Programming
Answers
Answers
Data
Machine Learning
Rules

Activity Recognition

```
01010010101001010
10100101010100101
11010100101010010
10100101010010101
00101010
```

Label = WALKING

```
10101001010010101
01010101001001001
00010010011111010
10111110101001001
11101011
```

Label = RUNNING

```
10010100111110101
01110101011101010
11101010101111010
10101111111100011
11010101
```

Label = BIKING

```
11111111110100111
01001111101011111
01010101110101010
10111010101010101
00111110
```

Label = GOLFING (Sort of)

X = -1, 0, 1, 2, 3, 4

Y = -3, -1, 1, 3, 5, 7

```
model = tf.keras.Sequential([keras.layers.Dense(units=1, input_shape=[1])])
model.compile(optimizer='sgd', loss='mean_squared_error')

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.fit(xs, ys, epochs=500)

print(model.predict([10.0]))
```

```
model = tf.keras.Sequential([keras.layers.Dense(units=1, input_shape=[1])])
model.compile(optimizer='sgd', loss='mean_squared_error')

xs = np.array([-1.0, 0.0, 1.0, 2.0, 3.0, 4.0], dtype=float)
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model.compile(optimizer='sgd', loss='mean_squared_error')

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.fit(xs, ys, epochs=500)

print(model.predict([10.0]))
```

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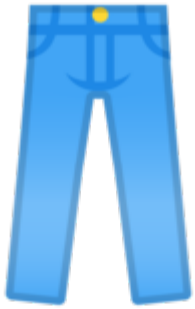
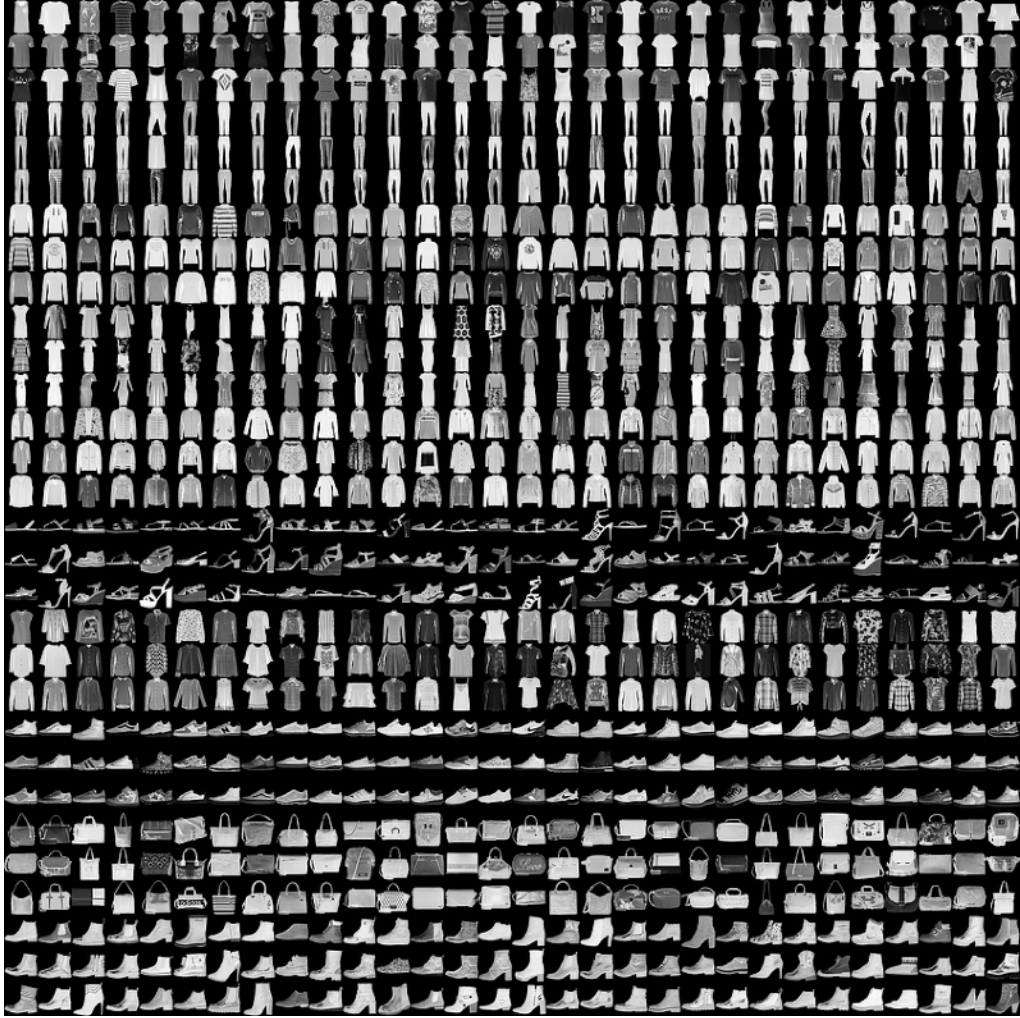


Fashion MNIST

- 70k Images
- 10 Categories
- Images are 28x28
- Can train a neural net!



Fashion MNIST

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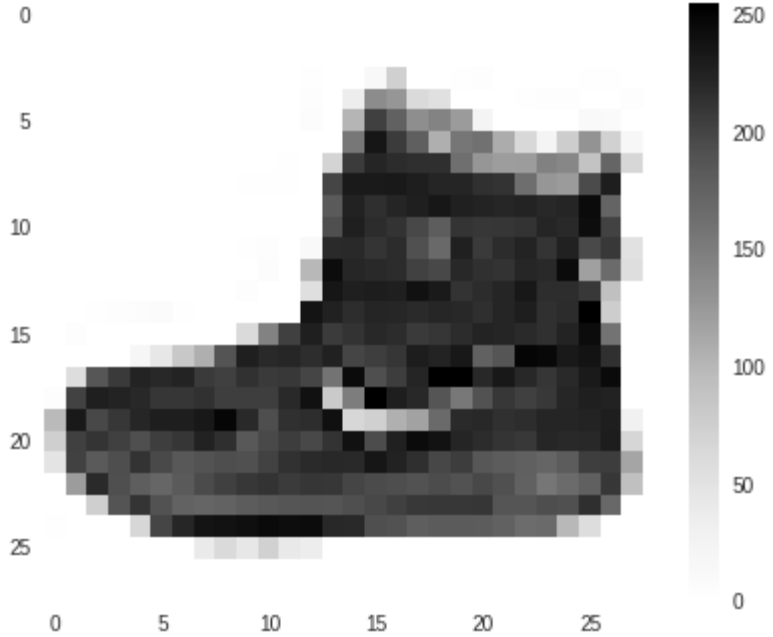
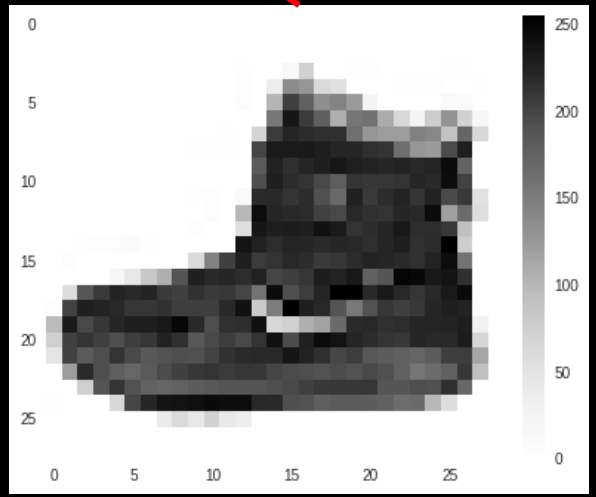


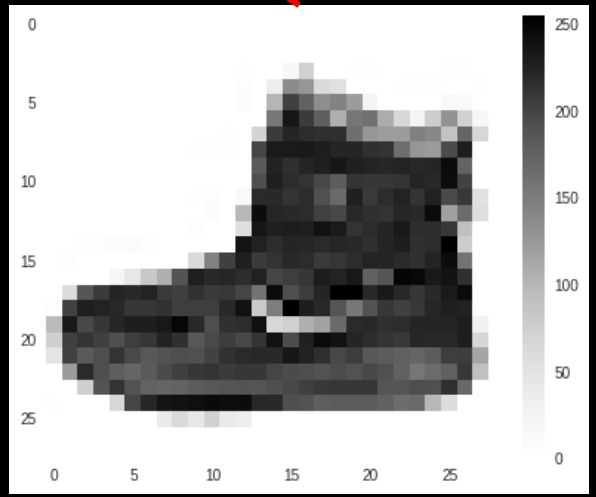
```
fashion_mnist = tf.keras.datasets.fashion_mnist

(train_images, train_labels), (test_images, test_labels) = fashion_mnist.load_data()
```

```
fashion_mnist = tf.keras.datasets.fashion_mnist
(train_images, train_labels), (test_images, test_labels) = fashion_mnist.load_data()
```



0 9

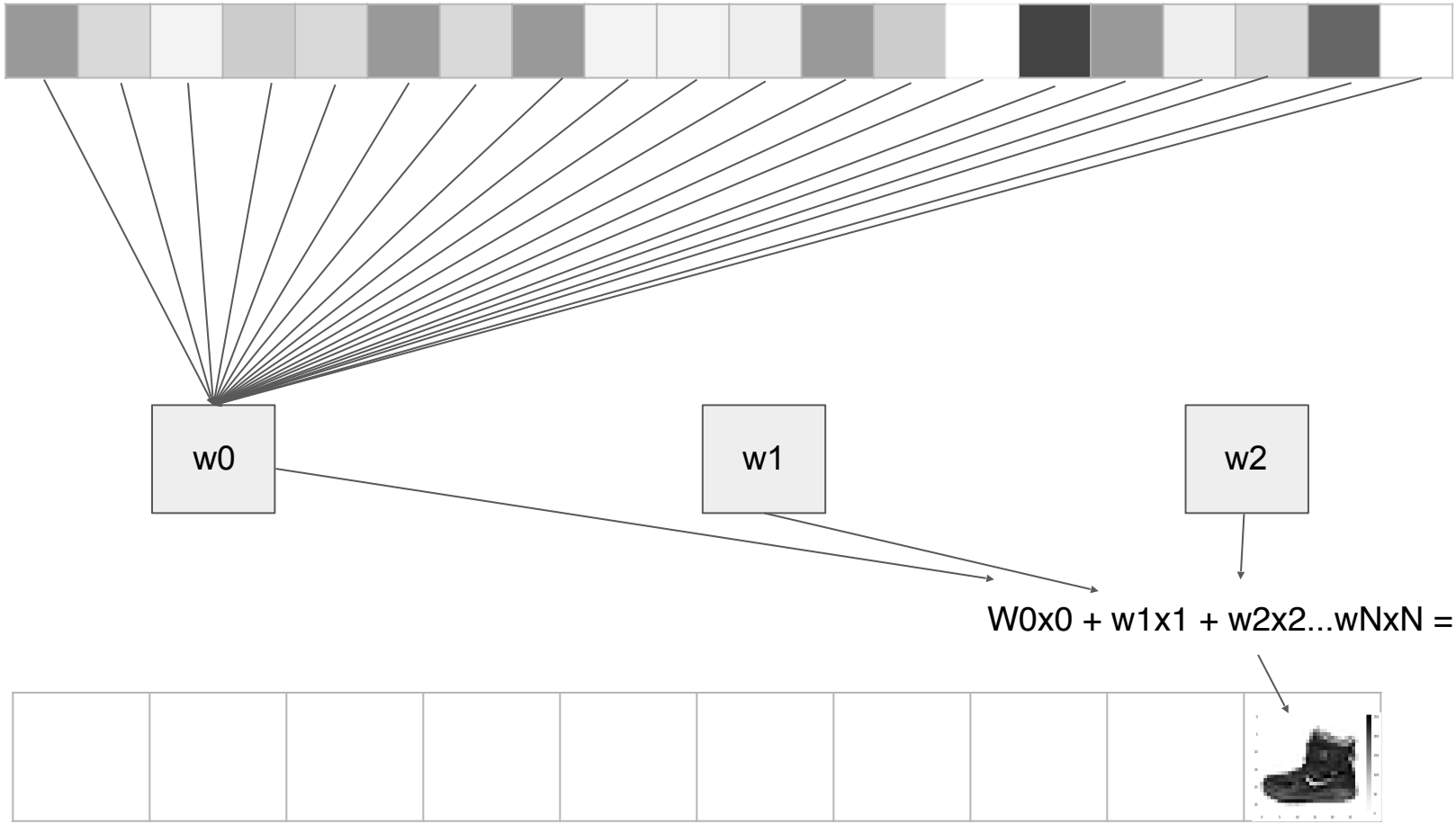
```
import tensorflow as tf
from tensorflow import keras

mnist = tf.keras.datasets.fashion_mnist
(train_images, train_labels), (test_images, test_labels) = mnist.load_data()
```



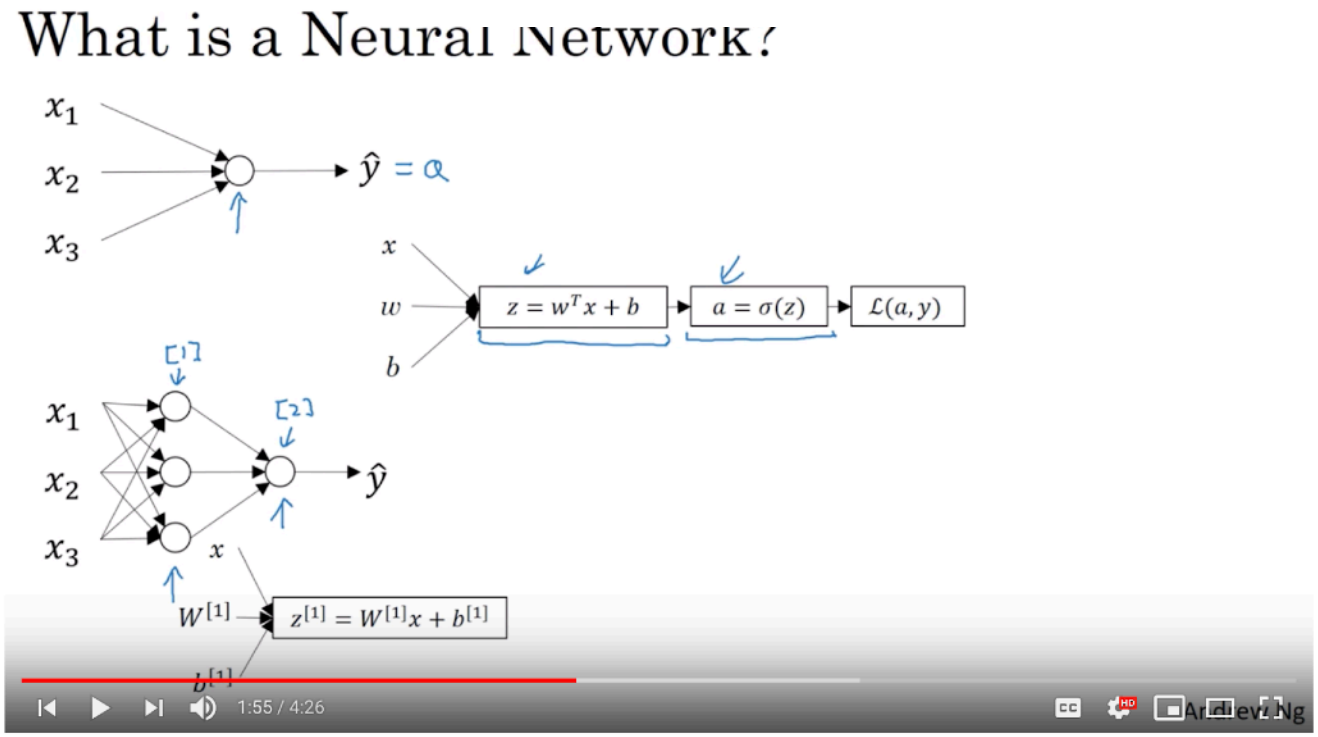
09

09 = ankle boot;
踝靴;
アンクルブーツ;
Bróg rúitín

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


w0
w1
w2
W0x0 + w1x1 + w2x2...wNxN = 9

https://youtu.be/fXOsFF95ifk



Neural Network Overview (C1W3L01)

11,067 views

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- Neural Network Overview (C1W3L01) — Deeplearning.ai — 4:27
- 26 Neural Network Representations (C1W3L02) — Deeplearning.ai — 5:15
- 27 Computing Neural Network Output (C1W3L03) — Deeplearning.ai — 9:58
- 28 Vectorizing Across Multiple Examples (C1W3L04) — Deeplearning.ai — 9:06
- 29 Explanation For Vectorized Implementation (C1W3L05) — Deeplearning.ai — 7:38
- 30 Activation Functions (C1W3L06) — Deeplearning.ai — 10:57

Complete User Registration system using PHP and MySQL... — Awa Melvine — 5.7M views — 32:43

```
mnist = tf.keras.datasets.fashion_mnist
(training_images, training_labels), (test_images, test_labels) = mnist.load_data()
training_images=training_images/255.0
test_images=test_images/255.0
model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(),
  tf.keras.layers.Dense(512, activation=tf.nn.relu),
  tf.keras.layers.Dense(10, activation=tf.nn.softmax)
])
model.compile(optimizer=tf.optimizers.Adam(), loss='sparse_categorical_crossentropy')
model.fit(training_images, training_labels, epochs=5)
```

```
mnist = tf.keras.datasets.fashion_mnist
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training_images=training_images/255.0
test_images=test_images/255.0
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])
model.compile(optimizer=tf.optimizers.Adam(), loss='sparse_categorical_crossentropy')
model.fit(training_images, training_labels, epochs=5)
```

```
class myCallback(tf.keras.callbacks.Callback):
  def on_epoch_end(self, epoch, logs={}):
    if(logs.get('loss')<0.4):
      print("\nLoss is low so cancelling training!")
      self.model.stop_training = True
```

```
class myCallback(tf.keras.callbacks.Callback):
  def on_epoch_end(self, epoch, logs={}):
    if(logs.get('loss')<0.4):
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```

```
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training_images=training_images/255.0
test_images=test_images/255.0
model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(),
  tf.keras.layers.Dense(512, activation=tf.nn.relu),
  tf.keras.layers.Dense(10, activation=tf.nn.softmax)
])
model.compile(optimizer=tf.optimizers.Adam()', loss='sparse_categorical_crossentropy')
model.fit(training_images, training_labels, epochs=5)
```

```
callbacks = myCallback()
mnist = tf.keras.datasets.fashion_mnist
(training_images, training_labels), (test_images, test_labels) = mnist.load_data()
training_images=training_images/255.0
test_images=test_images/255.0
model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(),
  tf.keras.layers.Dense(512, activation=tf.nn.relu),
  tf.keras.layers.Dense(10, activation=tf.nn.softmax)
])
model.compile(optimizer=tf.optimizers.Adam(), loss='sparse_categorical_crossentropy')
model.fit(training_images, training_labels, epochs=5)
```

```
callbacks = myCallback()

mnist = tf.keras.datasets.fashion_mnist
(training_images, training_labels), (test_images, test_labels) = mnist.load_data()
training_images=training_images/255.0
test_images=test_images/255.0
model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(),
  tf.keras.layers.Dense(512, activation=tf.nn.relu),
  tf.keras.layers.Dense(10, activation=tf.nn.softmax)
])
model.compile(optimizer=tf.optimizers.Adam(), loss='sparse_categorical_crossentropy')
model.fit(training_images, training_labels, epochs=5, callbacks=[callbacks])
```

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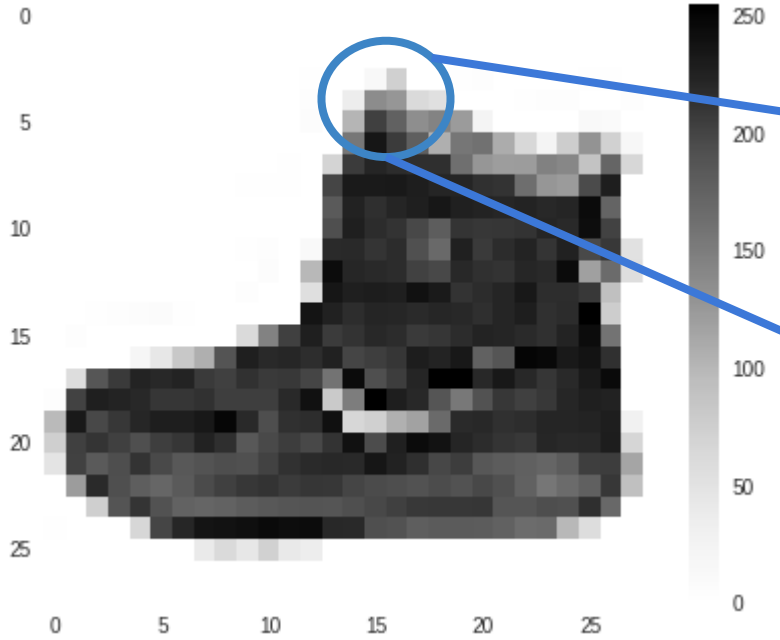


0	64	128
48	192	144
142	226	168

Current Pixel Value is 192

Consider neighbor Values

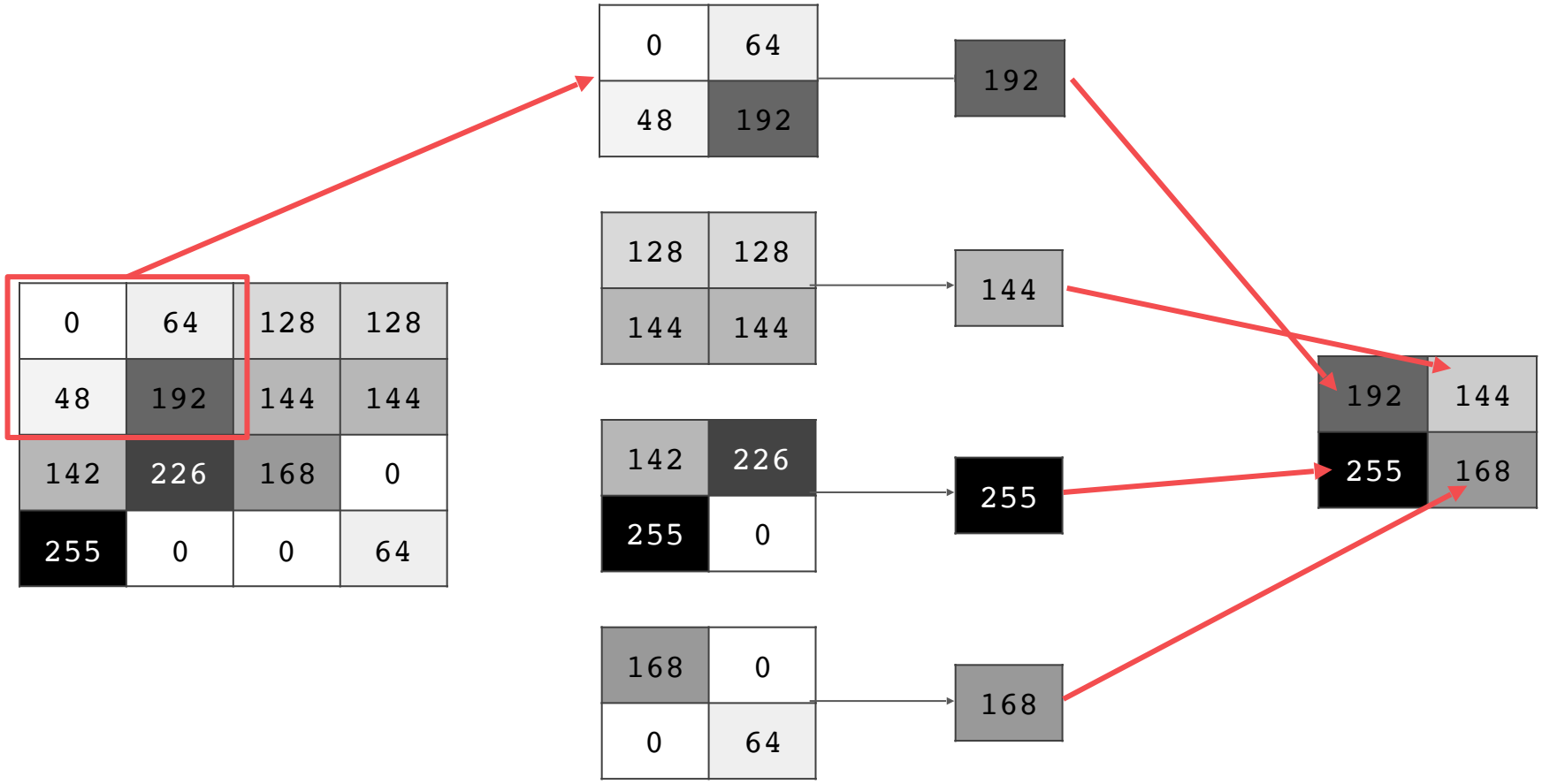
-1	0	-2
.5	4.5	-1.5
1.5	2	-3

Filter Definition

```
CURRENT_PIXEL_VALUE = 192
NEW_PIXEL_VALUE = (-1 * 0) + (0 * 64) + (-2 * 128) +
                  (.5 * 48) + (4.5 * 192) + (-1.5 * 144)
+
                  (1.5 * 142) + (2 * 226) + (-3 * 168)
```

−1	0	1
−2	0	2
−1	0	1

−1	−2	−1
0	0	0
1	2	1


0
64
128
128
48
192
144
144
142
226
168
0
255
0
0
64
0
64
48
192
128
128
144
144
142
226
255
0
168
0
0
64
192
144
255
168
168

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

```
model = tf.keras.models.Sequential([
  tf.keras.layers.Conv2D(64, (3,3), activation='relu',
                         input_shape=(28, 28, 1)),
  tf.keras.layers.MaxPooling2D(2, 2),
  tf.keras.layers.Conv2D(64, (3,3), activation='relu'),
  tf.keras.layers.MaxPooling2D(2,2),
  tf.keras.layers.Flatten(),
  tf.keras.layers.Dense(128, activation='relu'),
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```

```
model = tf.keras.models.Sequential([
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])
```

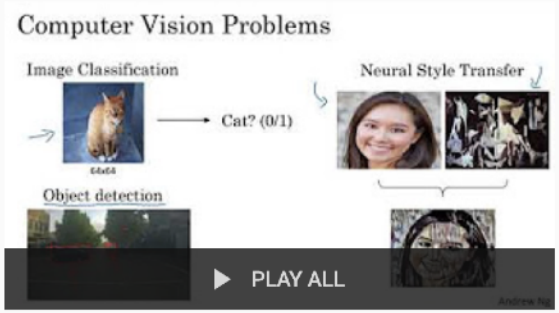

Convolutional Neural Networks (Course 4 of the Deep Learning Specialization)

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2 C4W1L02 Edge Detection Examples — Deeplearning.ai — 11:31

3 C4W1L03 More Edge Detection — Deeplearning.ai — 7:58

4 C4W1L04 Padding — Deeplearning.ai — 9:50

5 C4W1L05 Strided Convolutions — Deeplearning.ai — 9:02

6 C4W1L06 Convolutions Over Volumes — Deeplearning.ai — 10:45

https://bit.ly/2UGa7uH

```
model = tf.keras.models.Sequential([
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  tf.keras.layers.Conv2D(64, (3,3), activation='relu'),
  tf.keras.layers.MaxPooling2D(2,2),
  tf.keras.layers.Flatten(),
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  tf.keras.layers.Dense(10, activation='softmax')
])
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  tf.keras.layers.Flatten(),
  tf.keras.layers.Dense(128, activation='relu'),
  tf.keras.layers.Dense(10, activation='softmax')
])
```
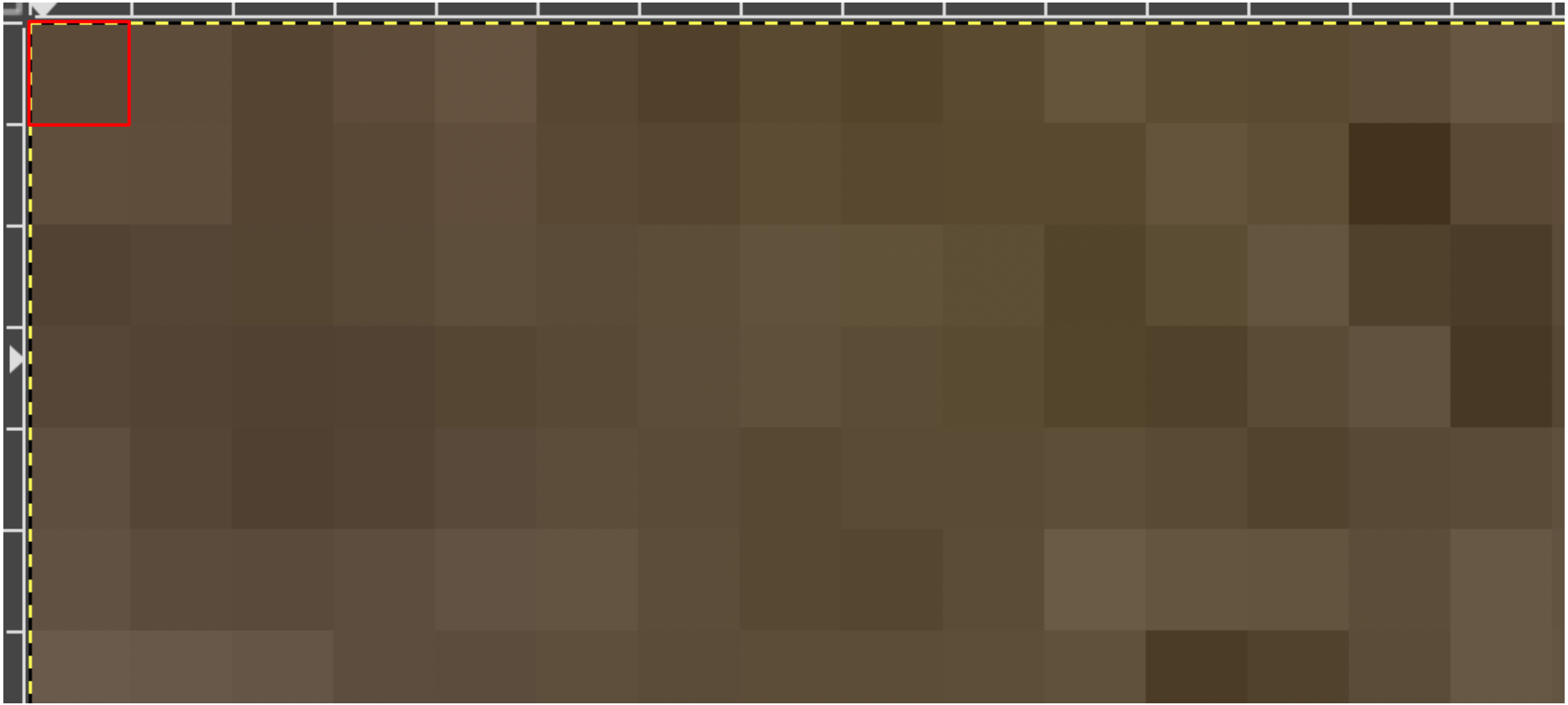
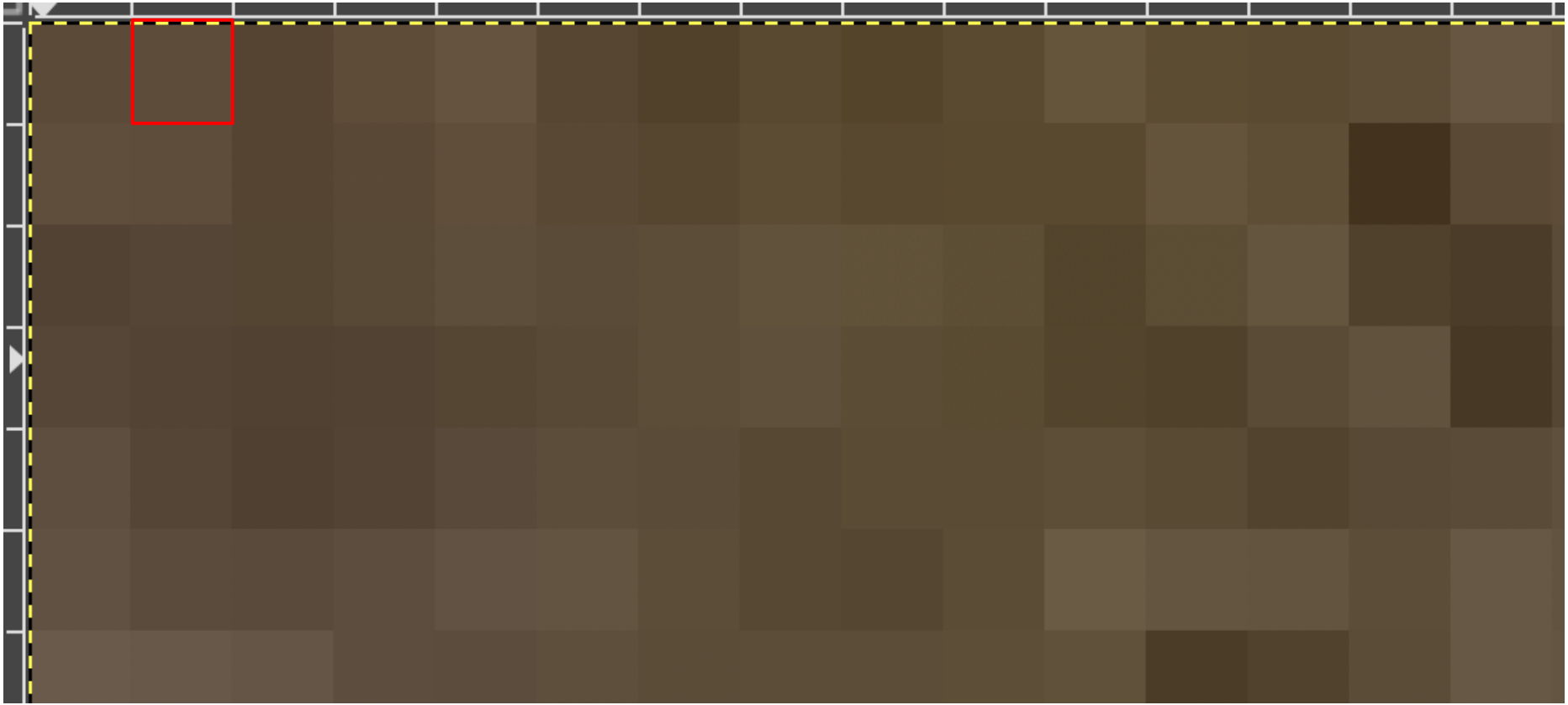
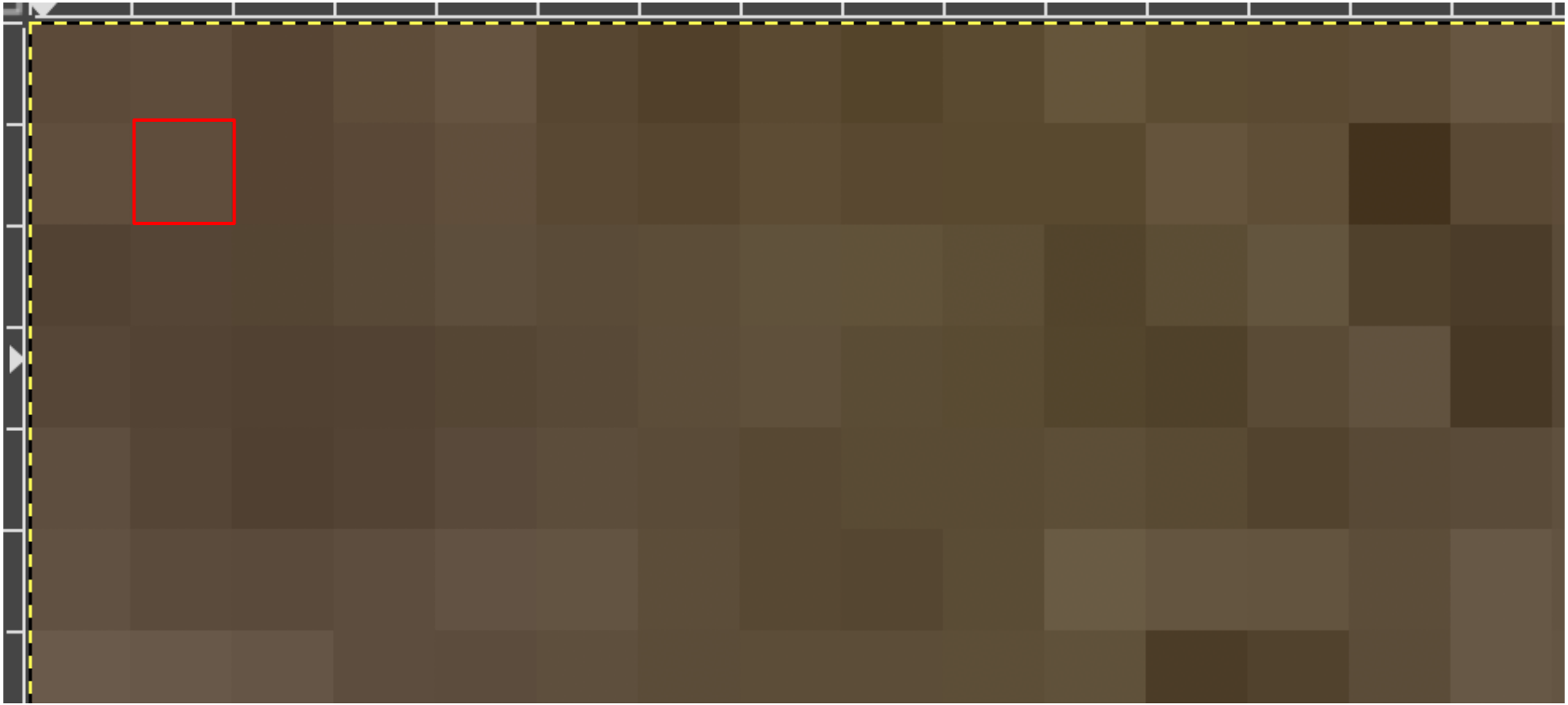

```
model.summary()
```

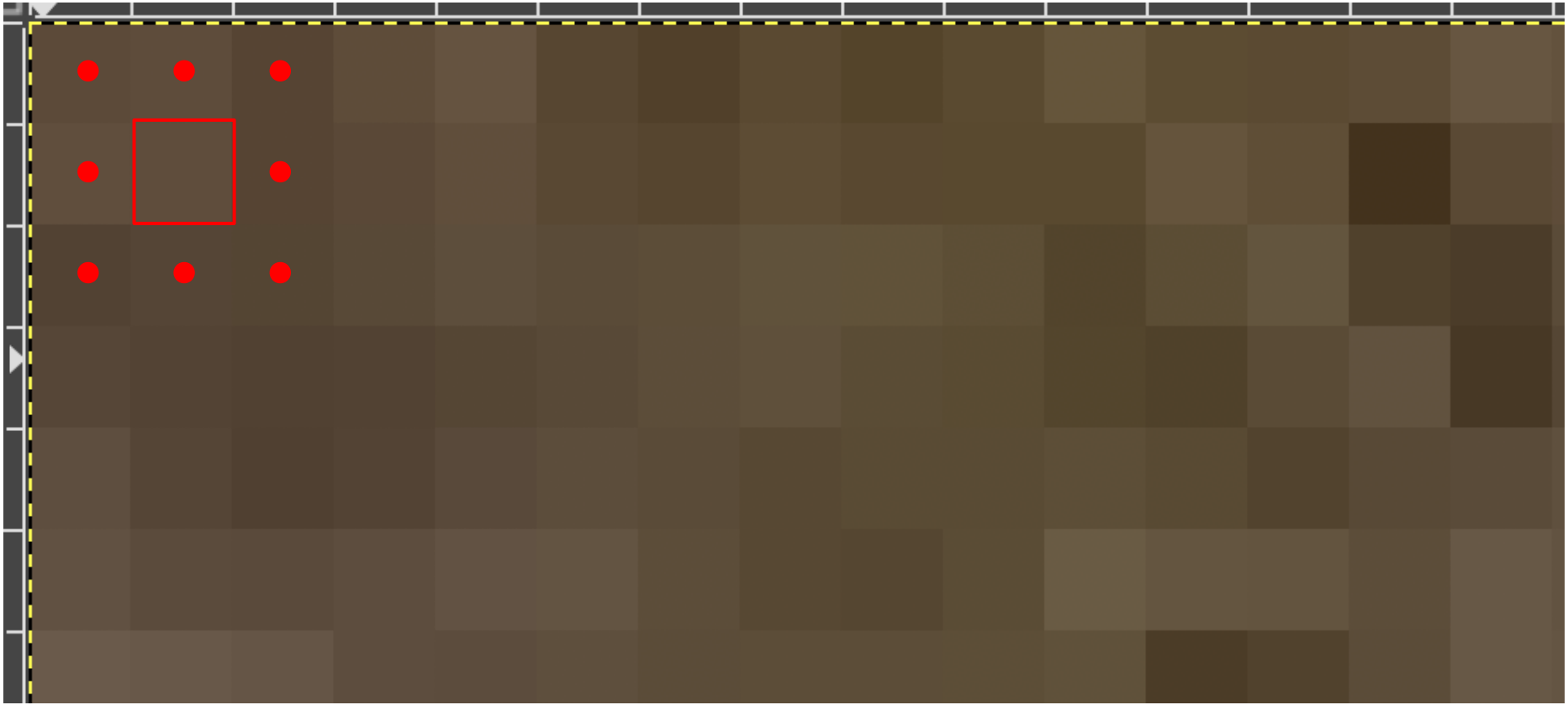
Layer (type)	Output Shape	Param #
conv2d_12 (Conv2D)	(None, 26, 26, 64)	640
max_pooling2d_12 (MaxPooling	(None, 13, 13, 64)	0
conv2d_13 (Conv2D)	(None, 11, 11, 64)	36928
max_pooling2d_13 (MaxPooling	(None, 5, 5, 64)	0
flatten_5 (Flatten)	(None, 1600)	0
dense_10 (Dense)	(None, 128)	204928
dense_11 (Dense)	(None, 10)	1290

Layer (type)	Output Shape	Param #
conv2d_12 (Conv2D)	(None, 26, 26, 64)	640
max_pooling2d_12 (MaxPooling	(None, 13, 13, 64)	0
conv2d_13 (Conv2D)	(None, 11, 11, 64)	36928
max_pooling2d_13 (MaxPooling	(None, 5, 5, 64)	0
flatten_5 (Flatten)	(None, 1600)	0
dense_10 (Dense)	(None, 128)	204928
dense_11 (Dense)	(None, 10)	1290









Layer (type)	Output Shape	Param #
conv2d_12 (Conv2D)	(None, 26, 26, 64)	640
max_pooling2d_12 (MaxPooling	(None, 13, 13, 64)	0
conv2d_13 (Conv2D)	(None, 11, 11, 64)	36928
max_pooling2d_13 (MaxPooling	(None, 5, 5, 64)	0
flatten_5 (Flatten)	(None, 1600)	0
dense_10 (Dense)	(None, 128)	204928
dense_11 (Dense)	(None, 10)	1290

Layer (type)	Output Shape	Param #
conv2d_12 (Conv2D)	(None, 26, 26, 64)	640
max_pooling2d_12 (MaxPooling	(None, 13, 13, 64)	0
conv2d_13 (Conv2D)	(None, 11, 11, 64)	36928
max_pooling2d_13 (MaxPooling	(None, 5, 5, 64)	0
flatten_5 (Flatten)	(None, 1600)	0
dense_10 (Dense)	(None, 128)	204928
dense_11 (Dense)	(None, 10)	1290

Layer (type)	Output Shape	Param #
conv2d_12 (Conv2D)	(None, 26, 26, 64)	640
max_pooling2d_12 (MaxPooling	(None, 13, 13, 64)	0
conv2d_13 (Conv2D)	(None, 11, 11, 64)	36928
max_pooling2d_13 (MaxPooling	(None, 5, 5, 64)	0
flatten_5 (Flatten)	(None, 1600)	0
dense_10 (Dense)	(None, 128)	204928
dense_11 (Dense)	(None, 10)	1290

Layer (type)	Output Shape	Param #
conv2d_12 (Conv2D)	(None, 26, 26, 64)	640
max_pooling2d_12 (MaxPooling	(None, 13, 13, 64)	0
conv2d_13 (Conv2D)	(None, 11, 11, 64)	36928
max_pooling2d_13 (MaxPooling	(None, 5, 5, 64)	0
flatten_5 (Flatten)	(None, 1600)	0
dense_10 (Dense)	(None, 128)	204928
dense_11 (Dense)	(None, 10)	1290

Layer (type)	Output Shape	Param #
conv2d_12 (Conv2D)	(None, 26, 26, 64)	640
max_pooling2d_12 (MaxPooling	(None, 13, 13, 64)	0
conv2d_13 (Conv2D)	(None, 11, 11, 64)	36928
max_pooling2d_13 (MaxPooling	(None, 5, 5, 64)	0
flatten_5 (Flatten)	(None, 1600)	0
dense_10 (Dense)	(None, 128)	204928
dense_11 (Dense)	(None, 10)	1290

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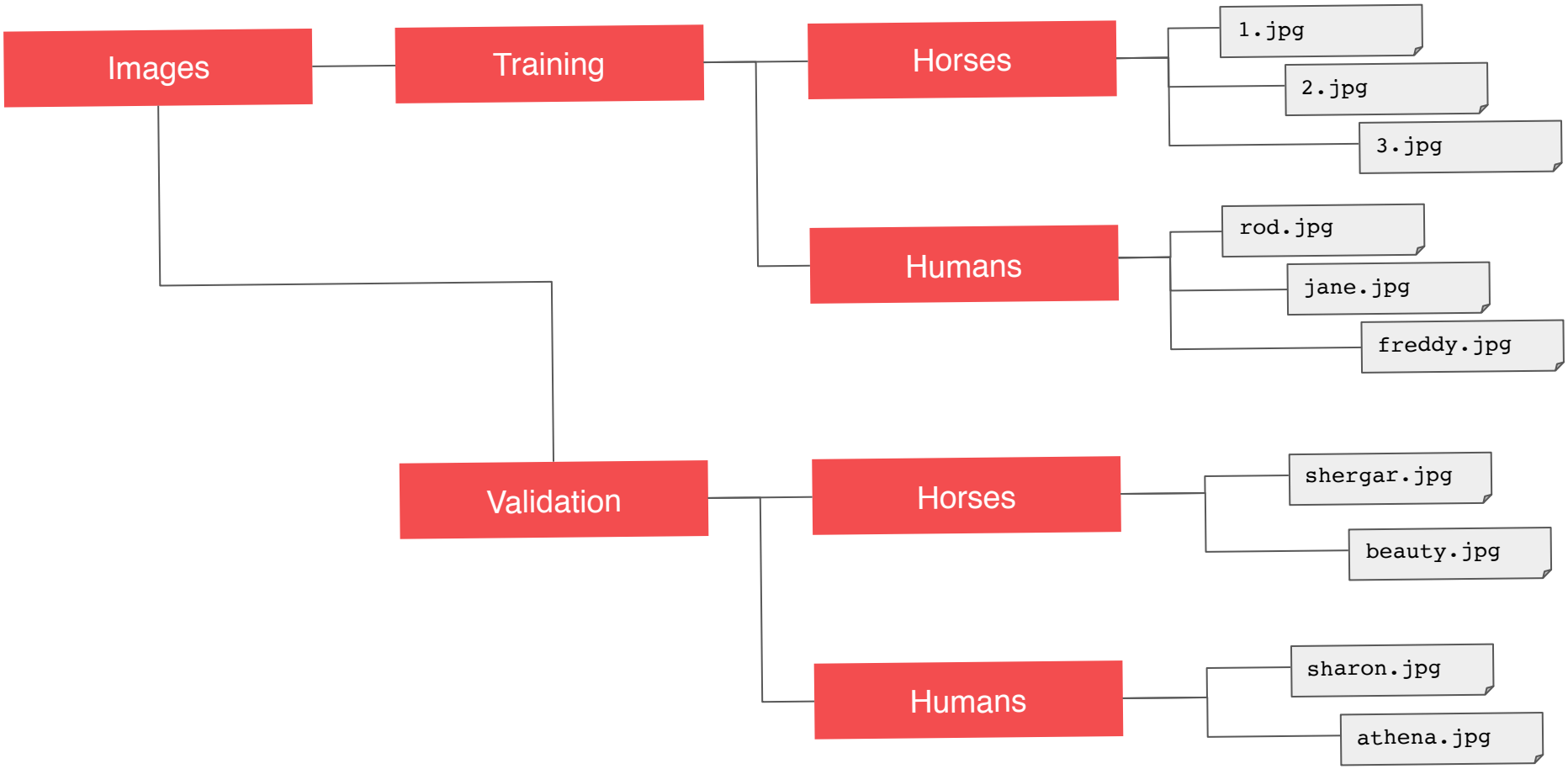
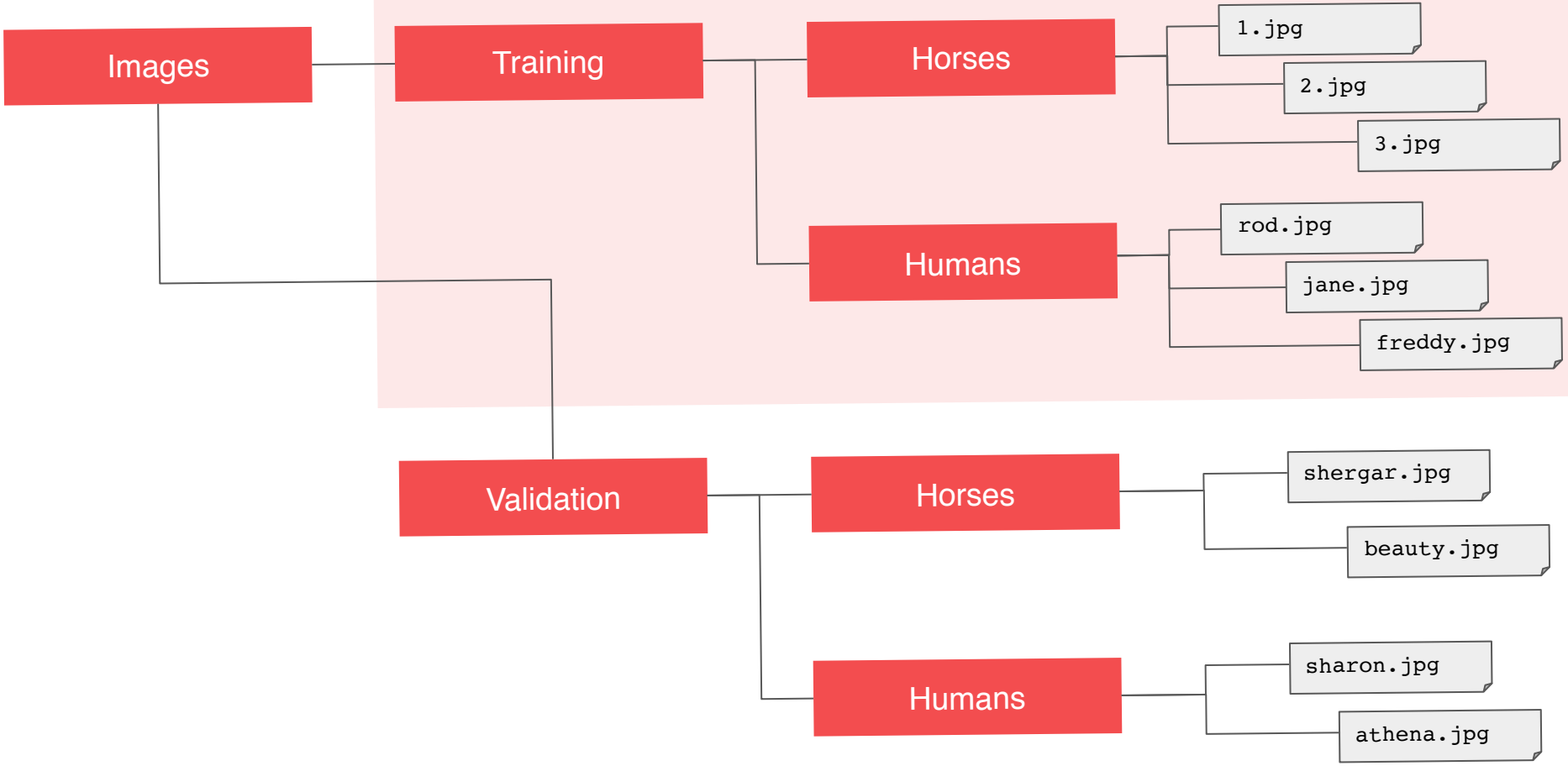
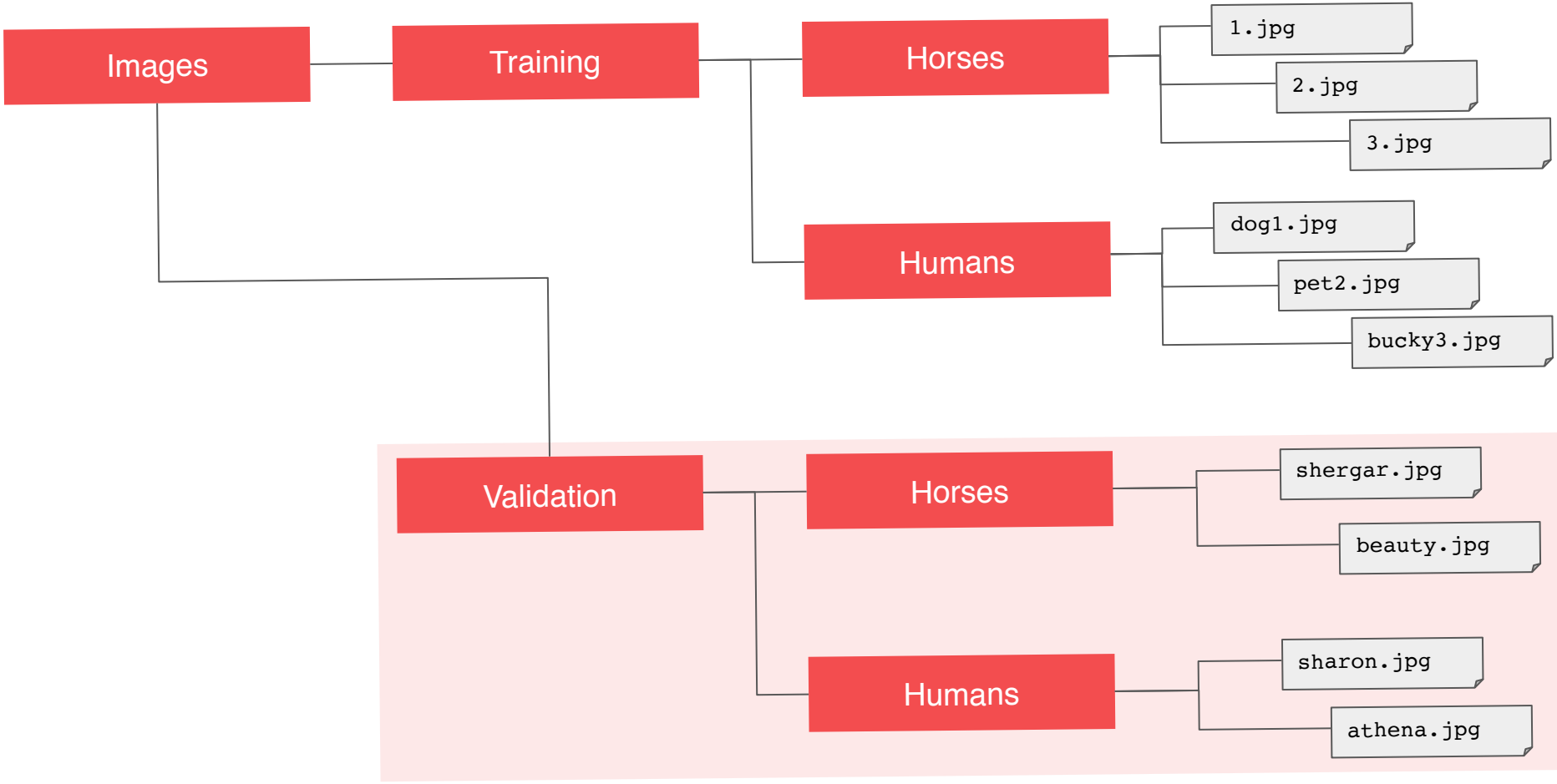

Images
Training
Horses
1.jpg
2.jpg
3.jpg
Humans
rod.jpg
jane.jpg
freddy.jpg
Validation
Horses
shergar.jpg
beauty.jpg
Humans
sharon.jpg
athena.jpg


Images
Training
Horses
1.jpg
2.jpg
3.jpg
Humans
rod.jpg
jane.jpg
freddy.jpg
Validation
Horses
shergar.jpg
beauty.jpg
Humans
sharon.jpg
athena.jpg


Images
Training
Horses
1.jpg
2.jpg
3.jpg
Humans
dog1.jpg
pet2.jpg
bucky3.jpg
Validation
Horses
shergar.jpg
beauty.jpg
Humans
sharon.jpg
athena.jpg

```
from tensorflow.keras.preprocessing.image
import ImageDataGenerator
```

```
train_datagen = ImageDataGenerator(rescale=1./255)

train_generator = train_datagen.flow_from_directory(
        train_dir,
        target_size=(300, 300),
        batch_size=128,
        class_mode='binary')
```

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train_datagen = ImageDataGenerator(rescale=1./255)

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        batch_size=128,
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```

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train_generator = train_datagen.flow_from_directory(
        train_dir,
        target_size=(300, 300),
        batch_size=128,
        class_mode='binary')
```

```
test_datagen = ImageDataGenerator(rescale=1./255)

validation_generator = test_datagen.flow_from_directory(
        validation_dir,
        target_size=(300, 300),
        batch_size=32,
        class_mode='binary')
```

```
model = tf.keras.models.Sequential([
    tf.keras.layers.Conv2D(16, (3,3), activation='relu',
                           input_shape=(300, 300, 3)),
    tf.keras.layers.MaxPooling2D(2, 2),
    tf.keras.layers.Conv2D(32, (3,3), activation='relu'),
    tf.keras.layers.MaxPooling2D(2,2),
    tf.keras.layers.Conv2D(64, (3,3), activation='relu'),
    tf.keras.layers.MaxPooling2D(2,2),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(512, activation='relu'),
    tf.keras.layers.Dense(1, activation='sigmoid')
])
```

```
model = tf.keras.models.Sequential([
    tf.keras.layers.Conv2D(16, (3,3), activation='relu',
                           input_shape=(300, 300, 3)),
    tf.keras.layers.MaxPooling2D(2, 2),
    tf.keras.layers.Conv2D(32, (3,3), activation='relu'),
    tf.keras.layers.MaxPooling2D(2,2),
    tf.keras.layers.Conv2D(64, (3,3), activation='relu'),
    tf.keras.layers.MaxPooling2D(2,2),
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```

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    tf.keras.layers.MaxPooling2D(2,2),
    tf.keras.layers.Conv2D(64, (3,3), activation='relu'),
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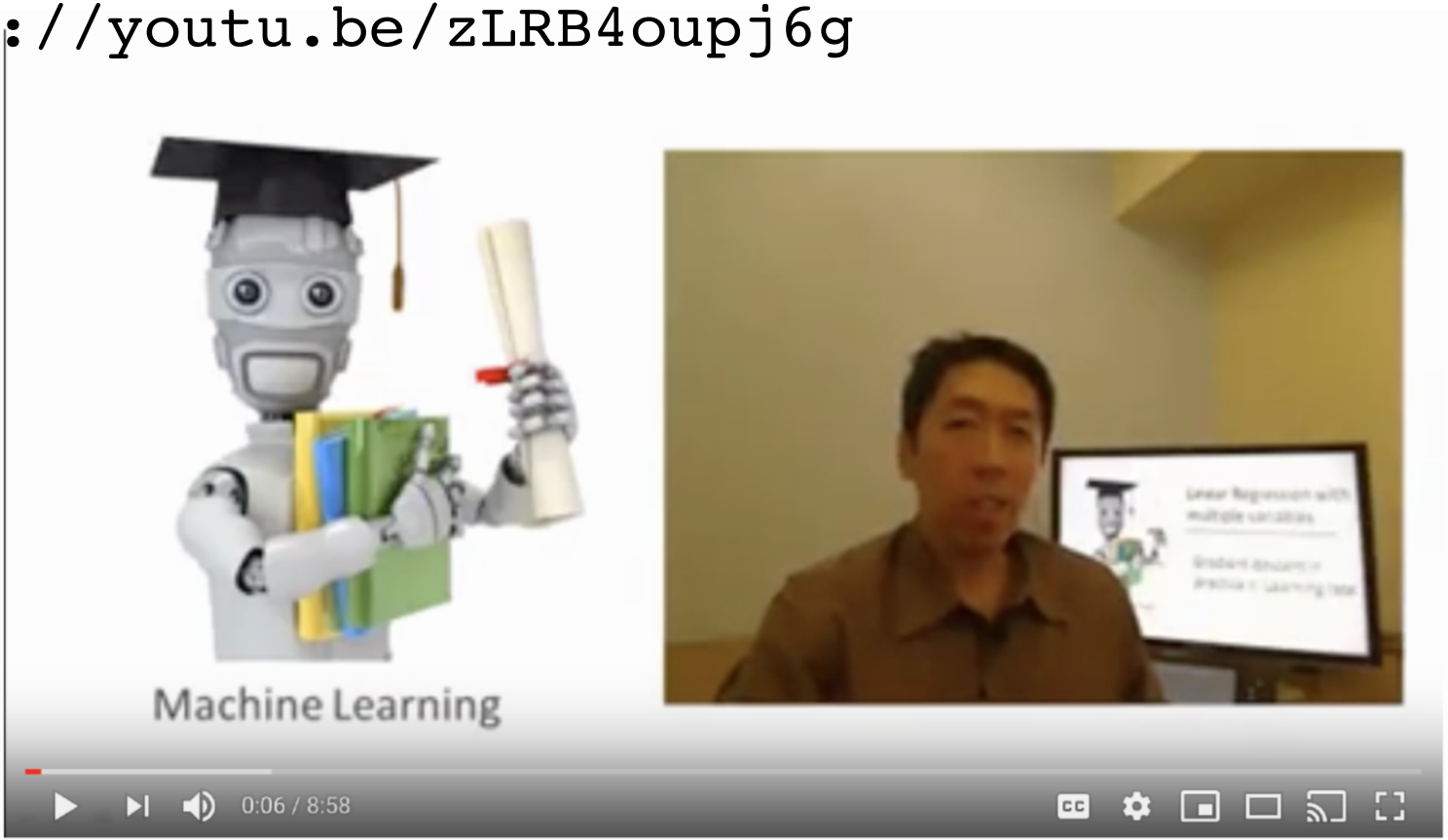
    tf.keras.layers.MaxPooling2D(2,2),
    tf.keras.layers.Conv2D(64, (3,3), activation='relu'),
    tf.keras.layers.MaxPooling2D(2,2),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(512, activation='relu'),
    tf.keras.layers.Dense(1, activation='sigmoid')
])
```

```
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_5 (Conv2D)            (None, 298, 298, 16)      448
_________________________________________________________________
max_pooling2d_5 (MaxPooling2 (None, 149, 149, 16)      0
_________________________________________________________________
conv2d_6 (Conv2D)            (None, 147, 147, 32)      4640
_________________________________________________________________
max_pooling2d_6 (MaxPooling2 (None, 73, 73, 32)        0
_________________________________________________________________
conv2d_7 (Conv2D)            (None, 71, 71, 64)        18496
_________________________________________________________________
max_pooling2d_7 (MaxPooling2 (None, 35, 35, 64)        0
_________________________________________________________________
flatten_1 (Flatten)          (None, 78400)             0
_________________________________________________________________
dense_2 (Dense)              (None, 512)               40141312
_________________________________________________________________
dense_3 (Dense)              (None, 1)                 513
=================================================================
Total params: 40,165,409
Trainable params: 40,165,409
Non-trainable params: 0
```

```
from tensorflow.keras.optimizers import RMSprop


model.compile(loss='binary_crossentropy',
              optimizer=RMSprop(lr=0.001),
              metrics=['accuracy'])
```

https://youtu.be/zLRB4oupj6g



2.1.4 Gradient Descent in Practice II Learning Rate by Andrew Ng

```
history = model.fit(
      train_generator,
      steps_per_epoch=8,
      epochs=15,
      validation_data=validation_generator,
      validation_steps=8,
      verbose=2)
```

```
history = model.fit(
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      validation_steps=8,
      verbose=2)
```

```
import numpy as np
from google.colab import files
from keras.preprocessing import image

uploaded = files.upload()

for fn in uploaded.keys():

  # predicting images
  path = '/content/' + fn
  img = image.load_img(path, target_size=(300, 300))
  x = image.img_to_array(img)
  x = np.expand_dims(x, axis=0)

  images = np.vstack([x])
  classes = model.predict(images, batch_size=10)
  print(classes[0])
  if classes[0]>0.5:
    print(fn + " is a human")
  else:
    print(fn + " is a horse")
```

```
import numpy as np
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for fn in uploaded.keys():

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