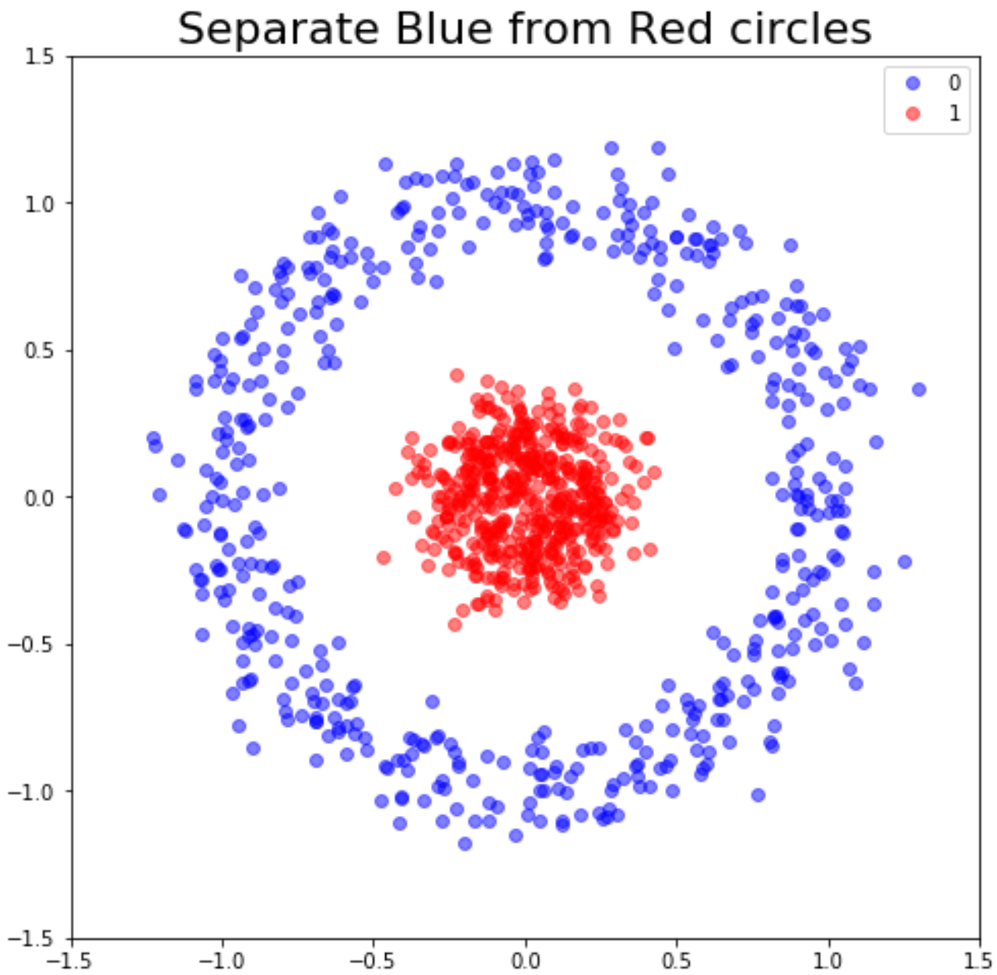
Binary classification

INTRODUCTION TO DEEP LEARNING WITH KERAS

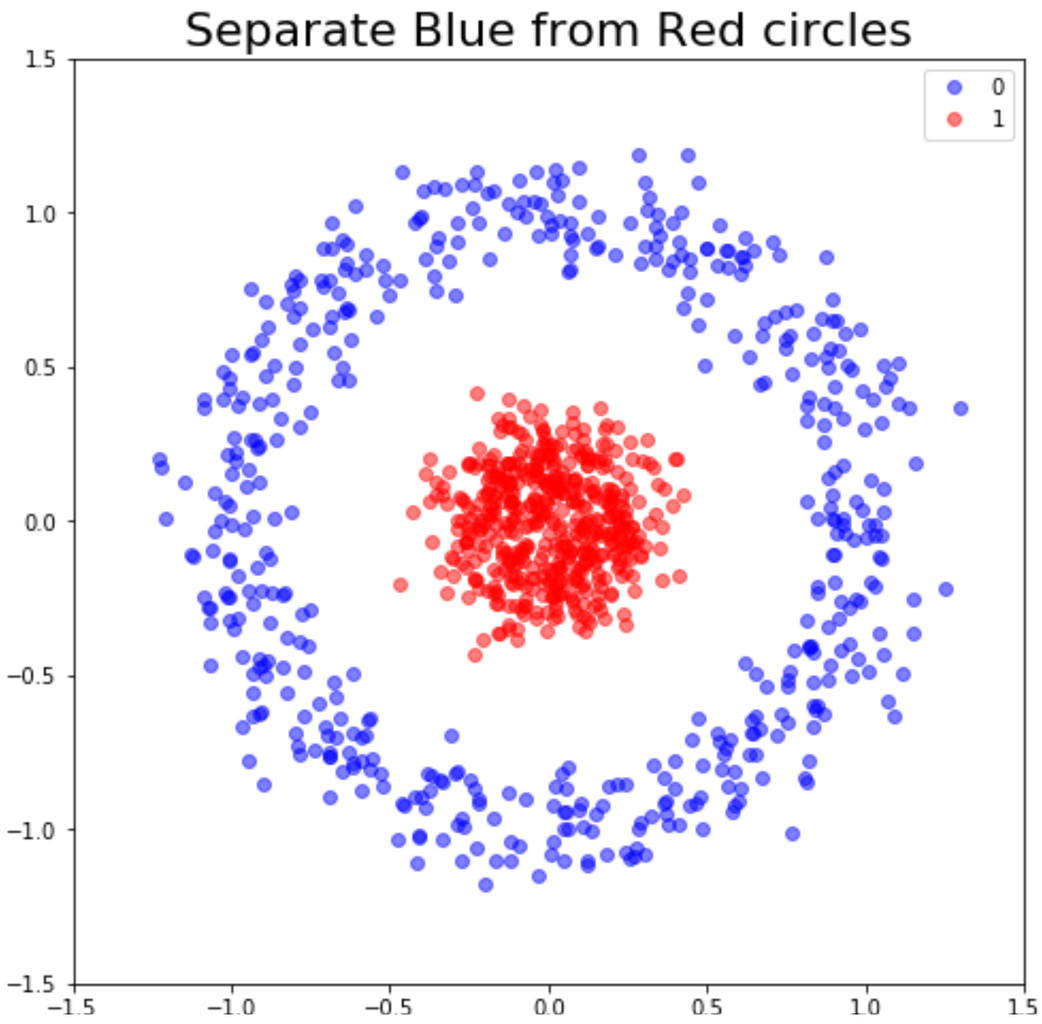
Miguel Esteban
Data Scientist & Founder

When to use binary classification?



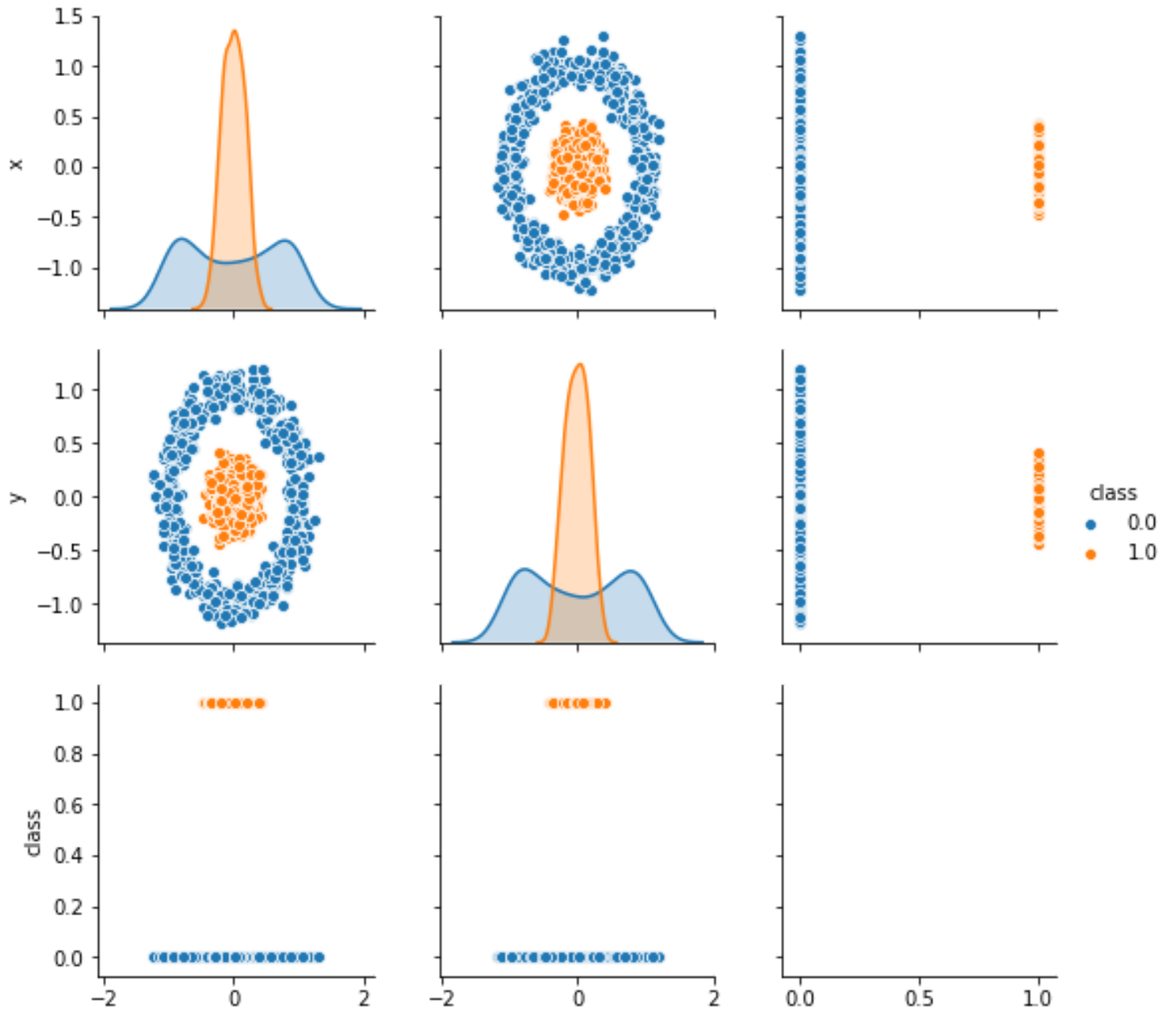
Our dataset

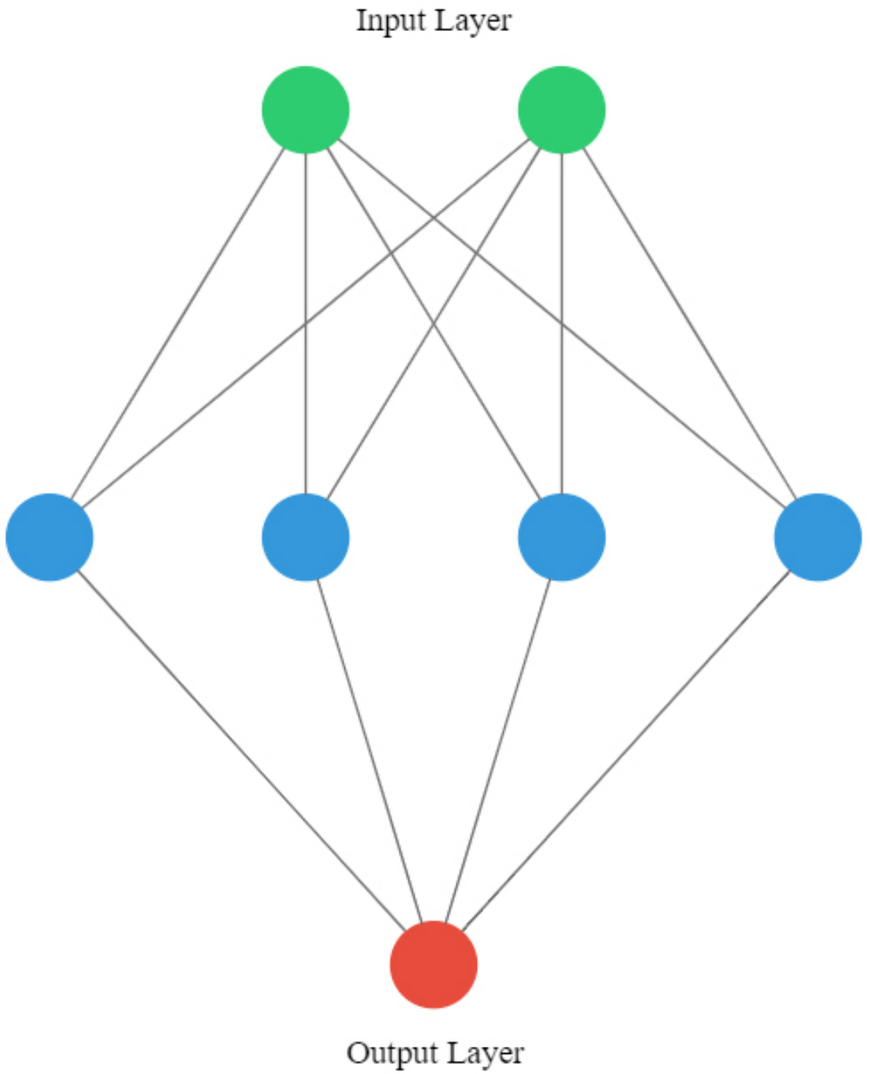
coordinates	labels
[0.242, 0.038]	1
[0.044, -0.057]	1
[-0.787, -0.076]	0

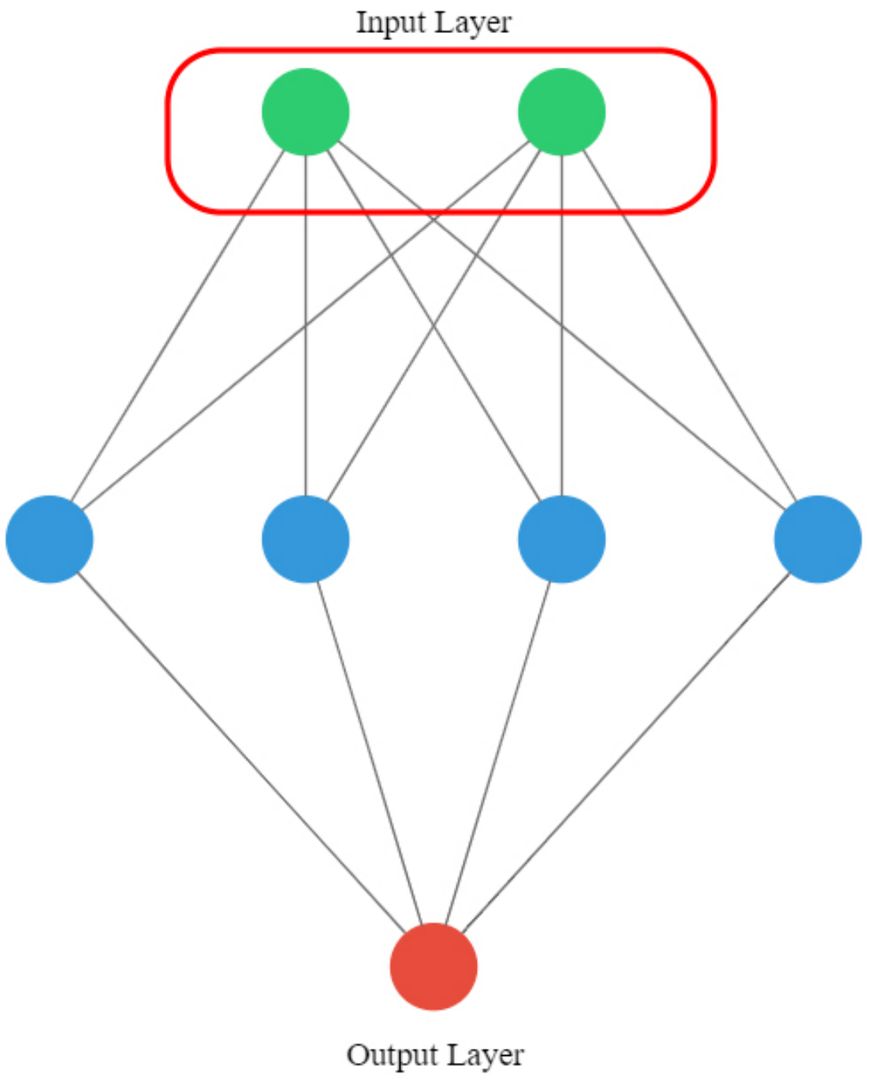


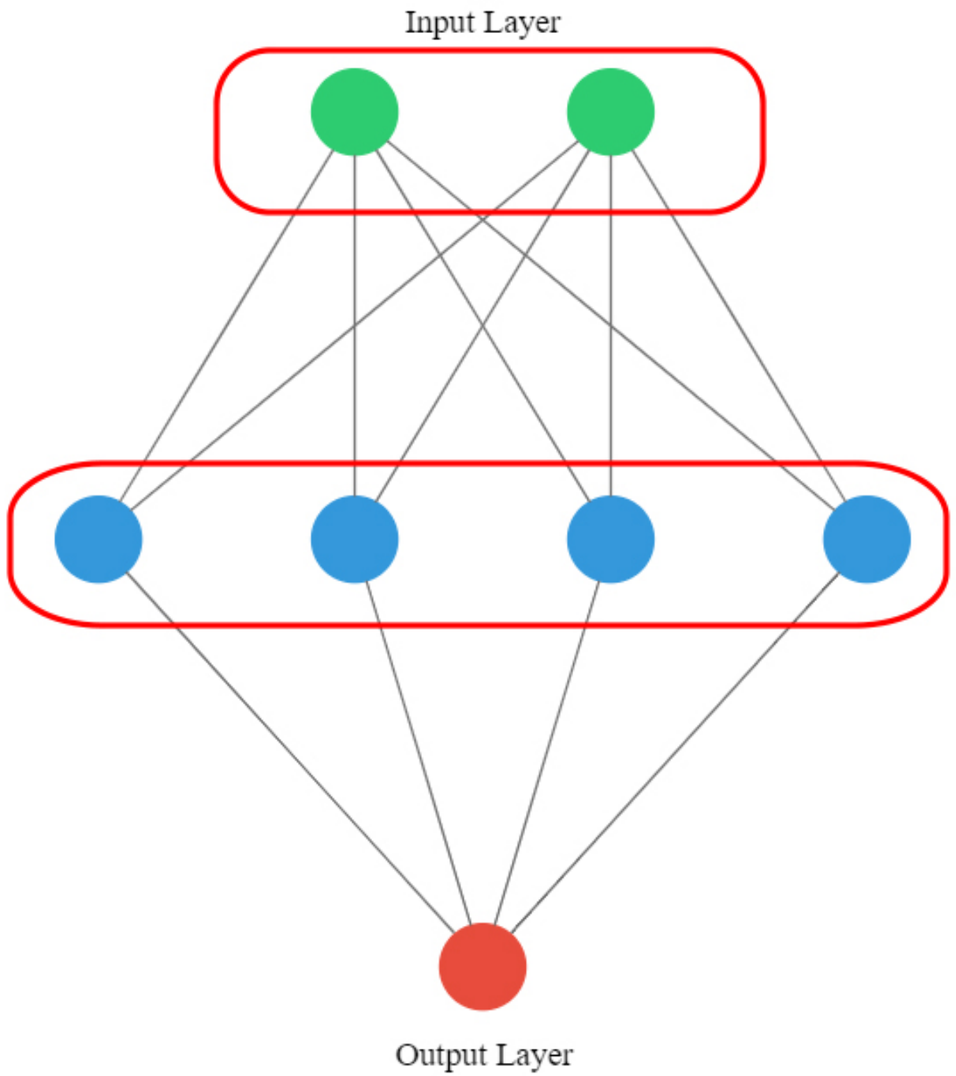
Pairplots

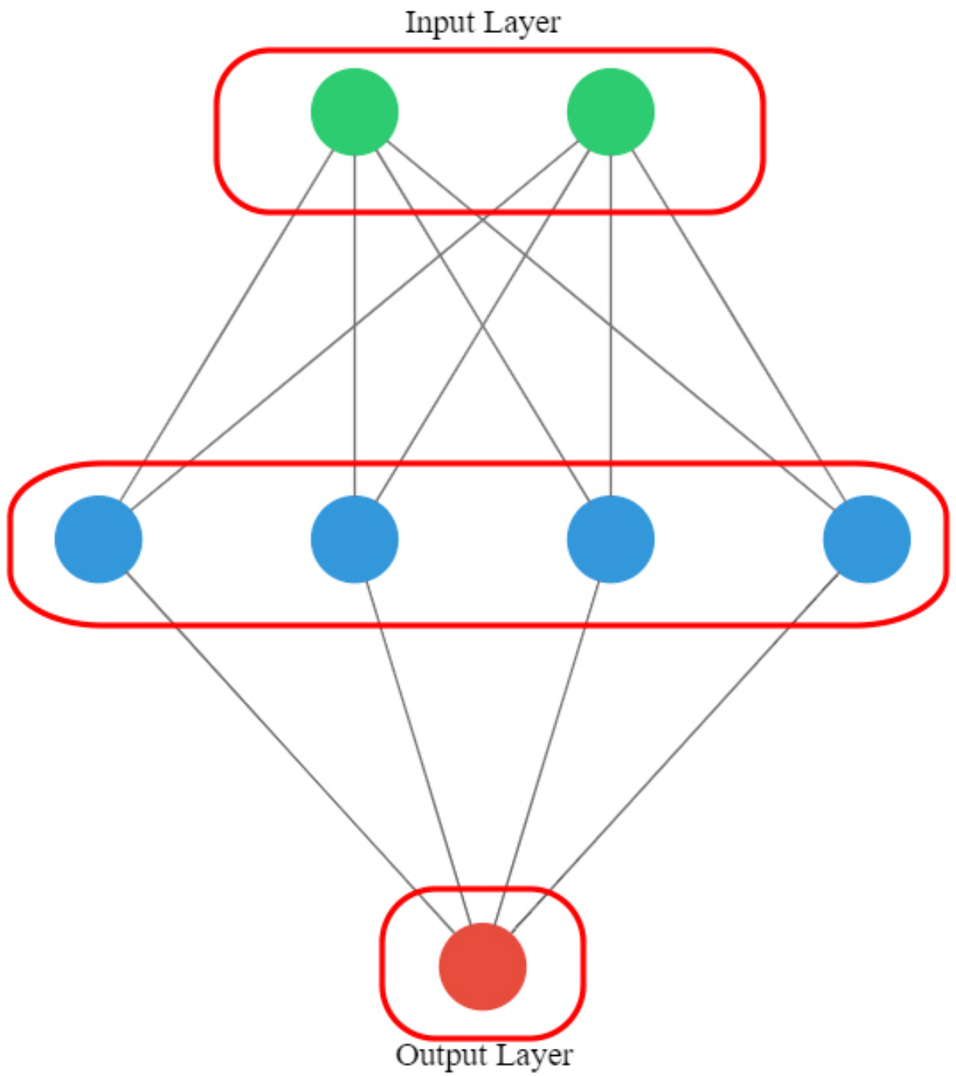
```
import seaborn as sns

# Plot a pairplot
sns.pairplot(circles, hue="target")
```

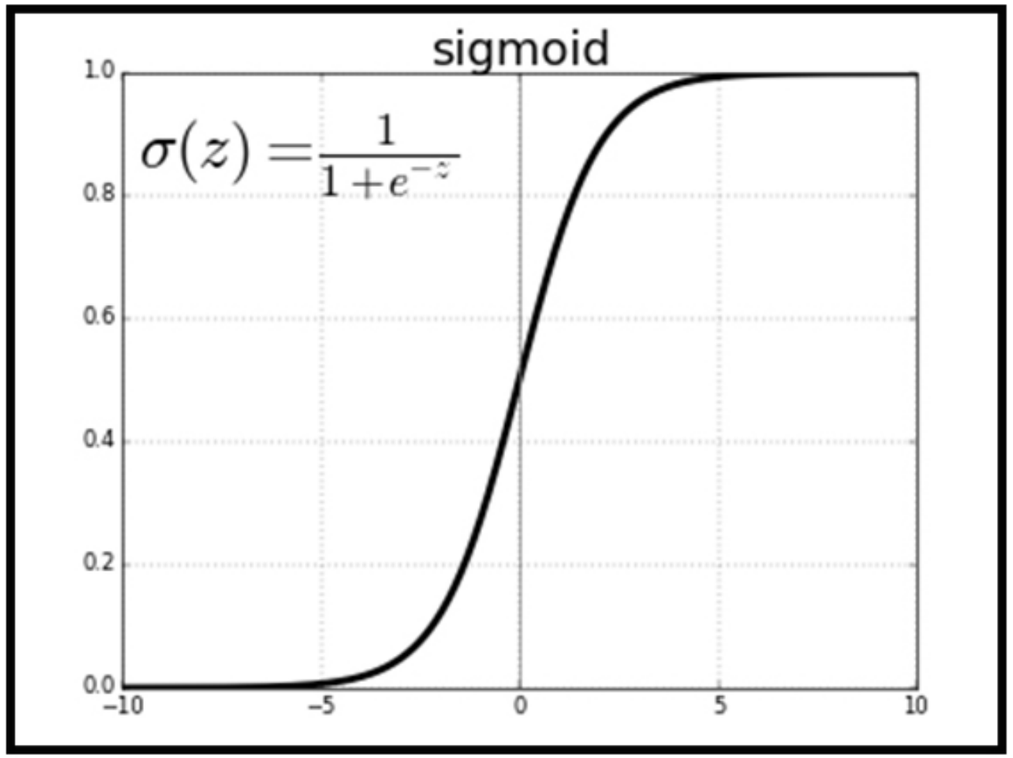



Input Layer
Output Layer


Input Layer
Output Layer

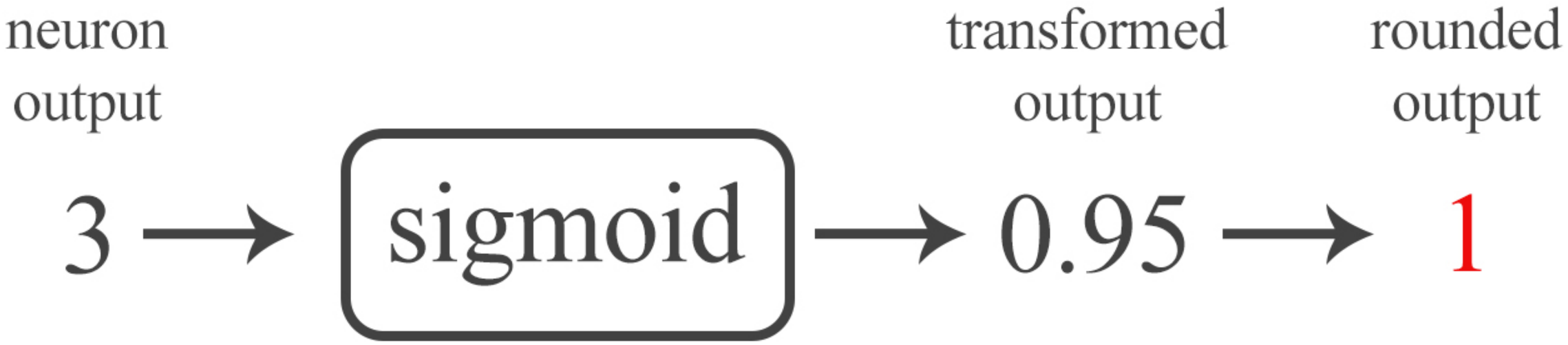

Input Layer
Output Layer


Input Layer
Output Layer



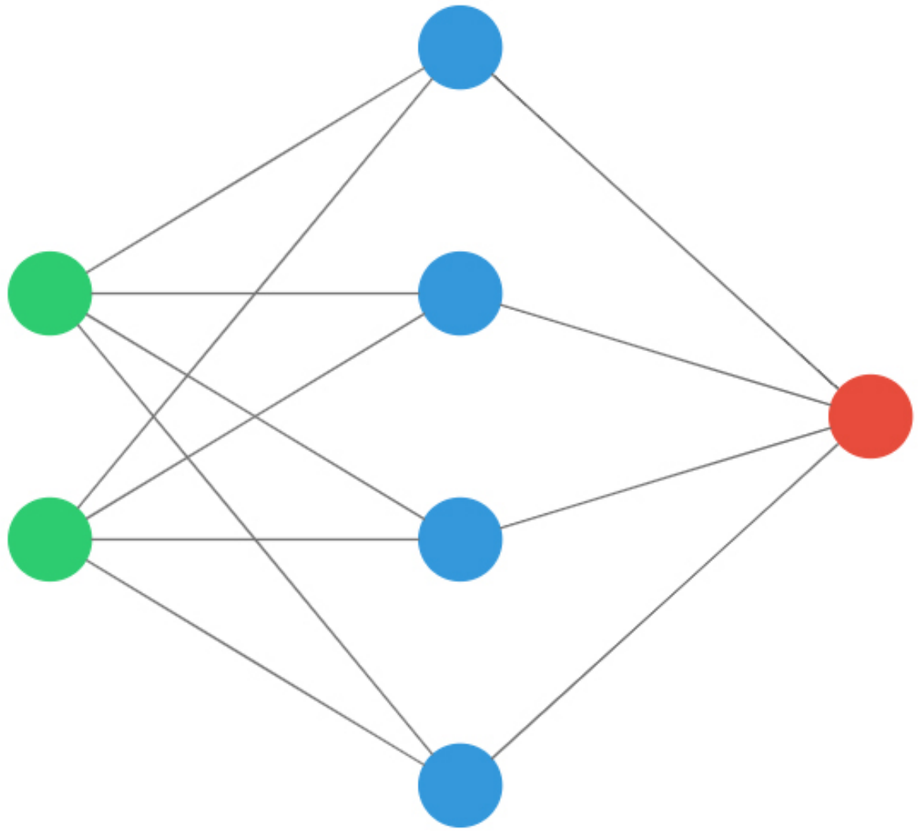
Output Layer

The sigmoid function



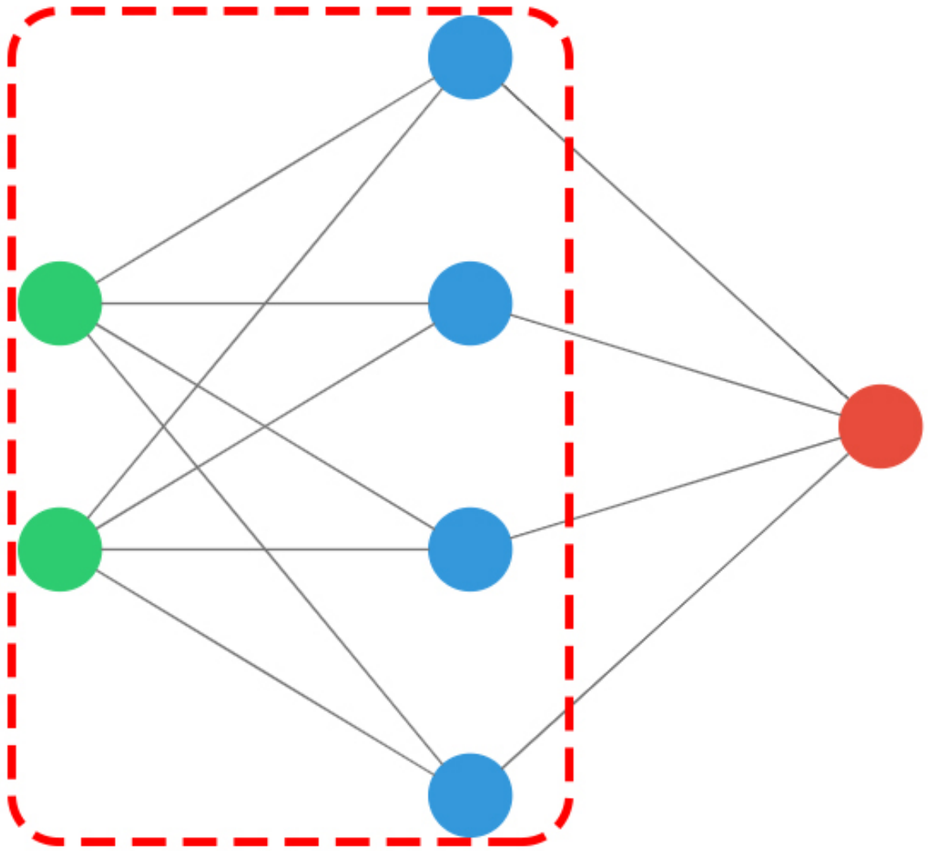
Let's build it

```
from keras.models import Sequential
from keras.layers import Dense

# Instantiate a sequential model
model = Sequential()
```



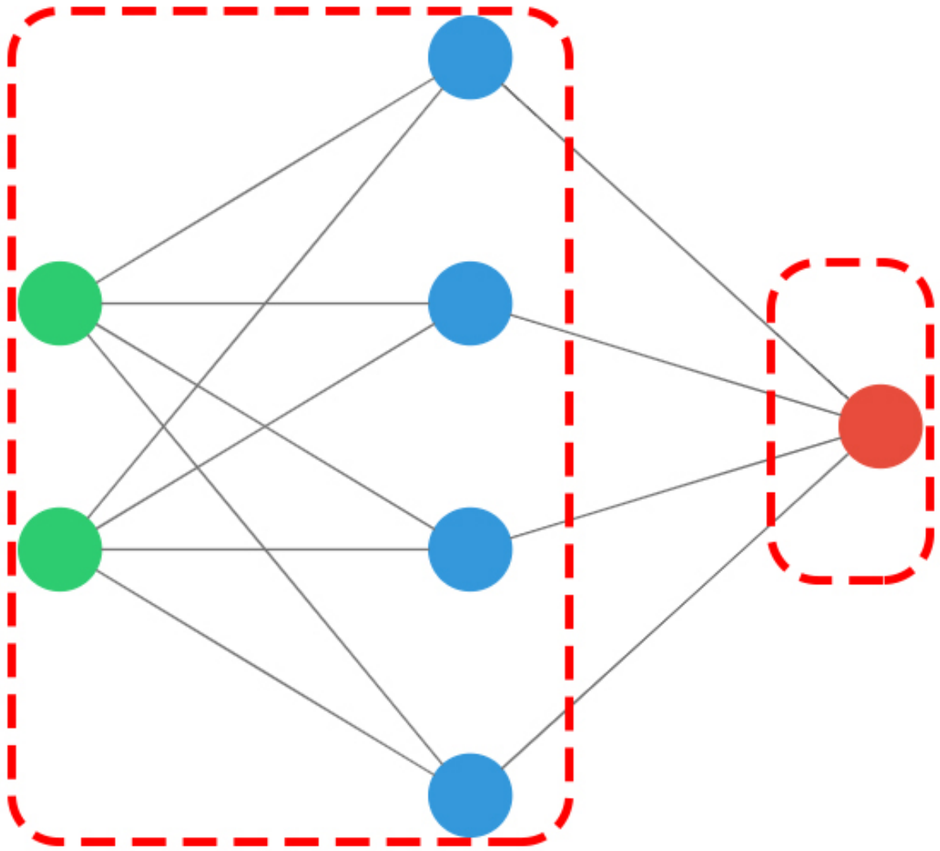
Let's build it

```
from keras.models import Sequential
from keras.layers import Dense

# Instantiate a sequential model
model = Sequential()

# Add input and hidden layer
model.add(Dense(4, input_shape=(2,),
                activation='tanh'))
```



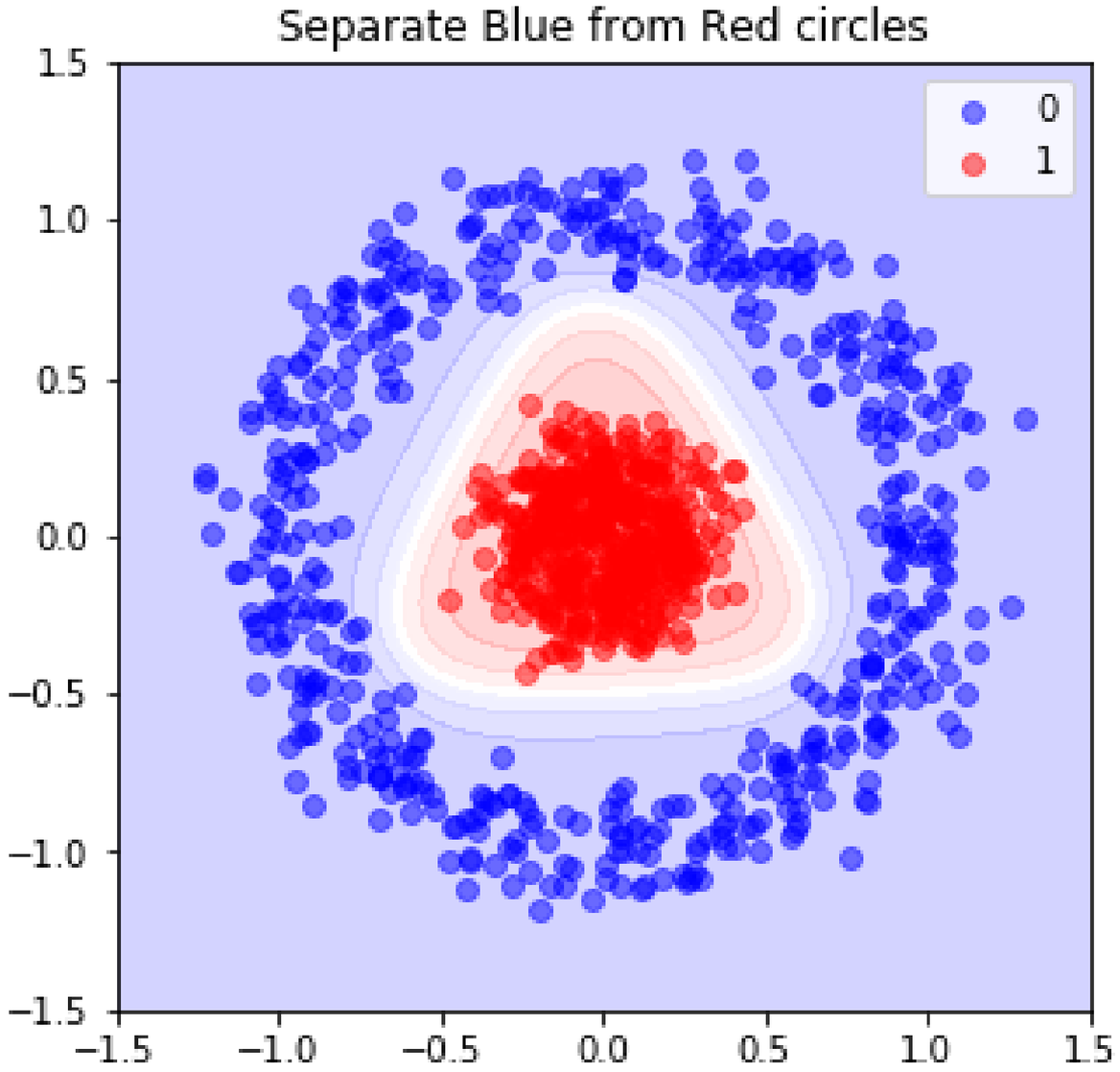
Let's build it

```
from keras.models import Sequential
from keras.layers import Dense

# Instantiate a sequential model
model = Sequential()

# Add input and hidden layer
model.add(Dense(4, input_shape=(2,),
                activation='tanh'))

# Add output layer, use sigmoid
model.add(Dense(1,
                activation='sigmoid'))
```



Compiling, training, predicting

```
# Compile model
model.compile(optimizer='sgd',
              loss='binary_crossentropy')

# Train model
model.train(coordinates, labels, epochs=20)

# Predict with trained model
preds = model.predict(coordinates)
```


Separate Blue from Red circles
0
1
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5

Let's practice!

INTRODUCTION TO DEEP LEARNING WITH KERAS

Multi-class classification

INTRODUCTION TO DEEP LEARNING WITH KERAS

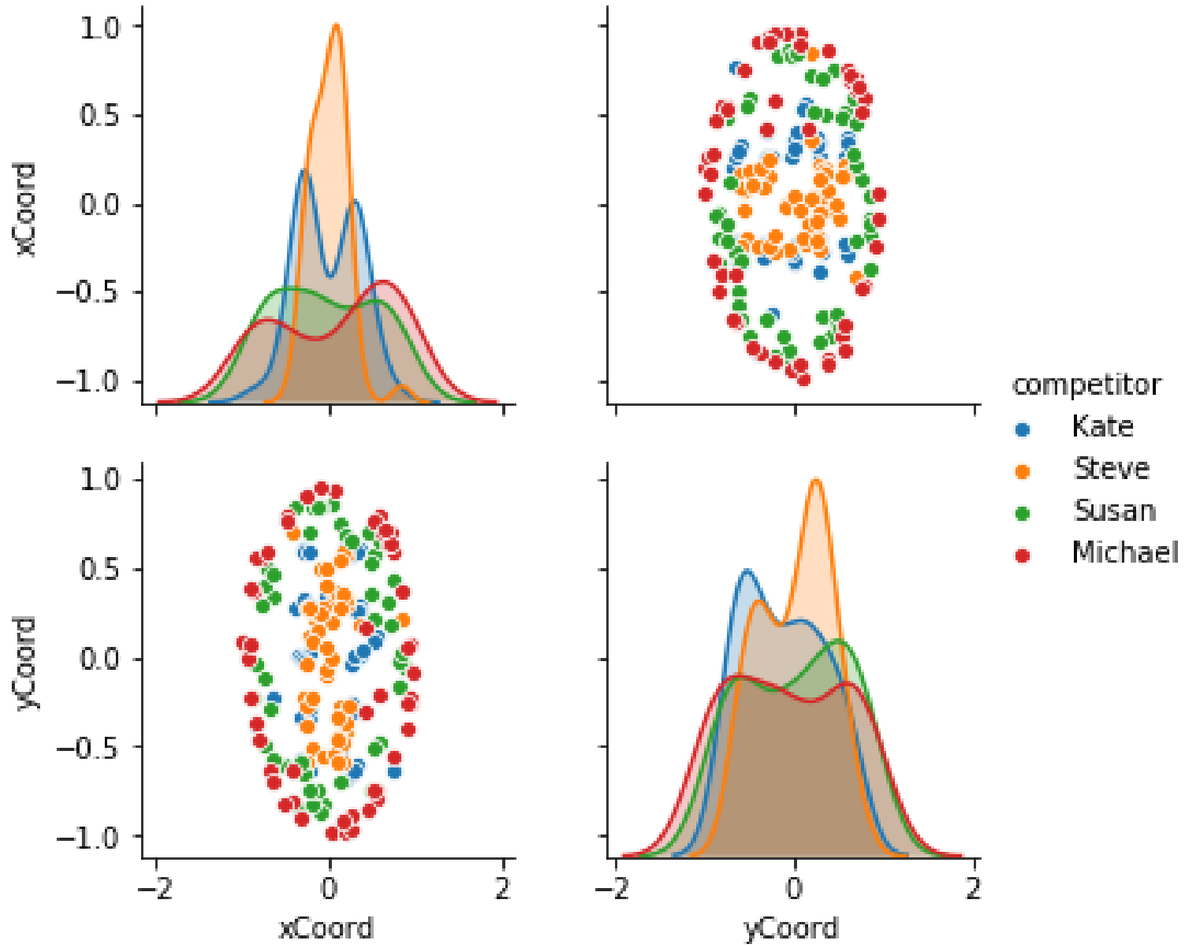
Miguel Esteban
Data Scientist & Founder

Throwing darts

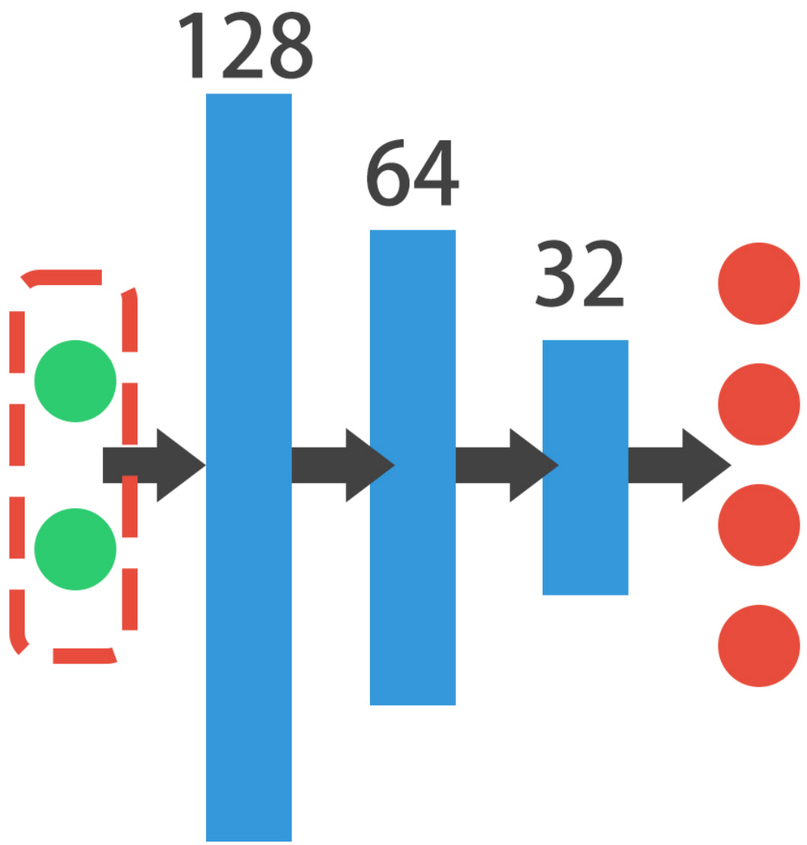
The dataset

xCoord	yCoord	competitor
-0.037673	0.057402	Steve
-0.331021	-0.585035	Susan
-0.123567	0.839730	Susan
-0.086160	0.959787	Michael
-0.902632	0.078753	Michael

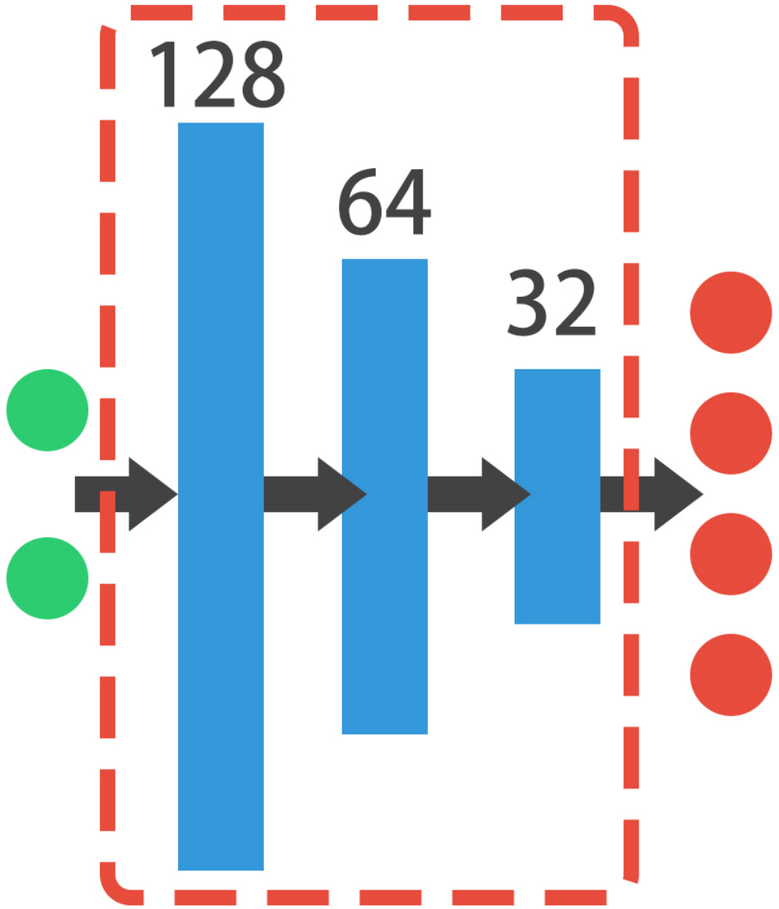
The dataset


1.0
0.5
0.0
−0.5
−1.0
xCoord
yCoord
−2
0
2
competitor
Kate
Steve
Susan
Michael

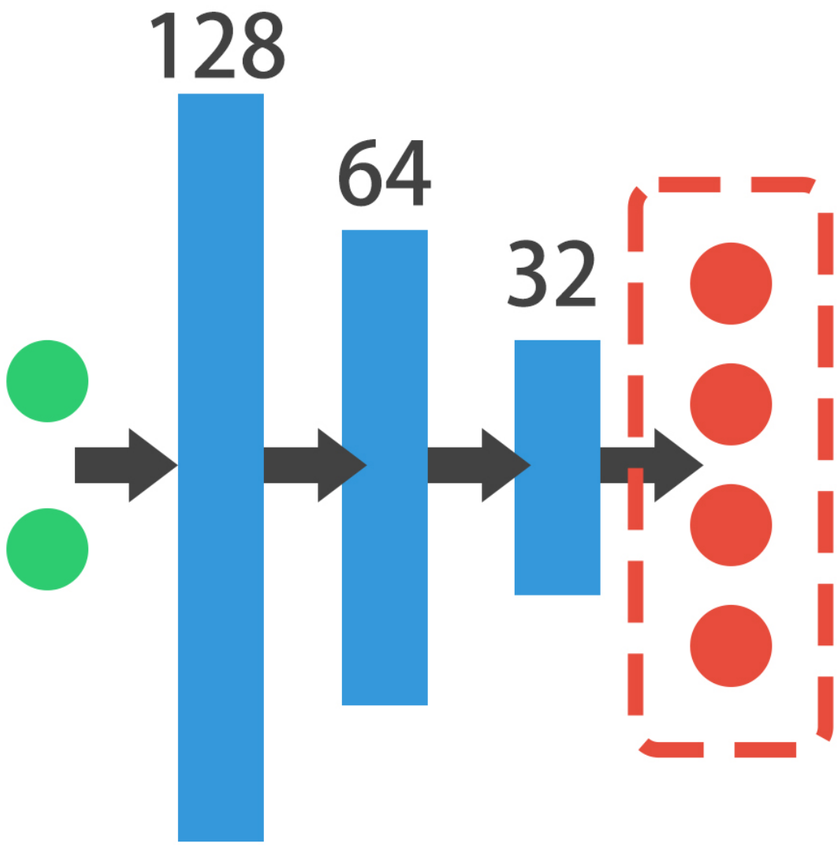
The architecture



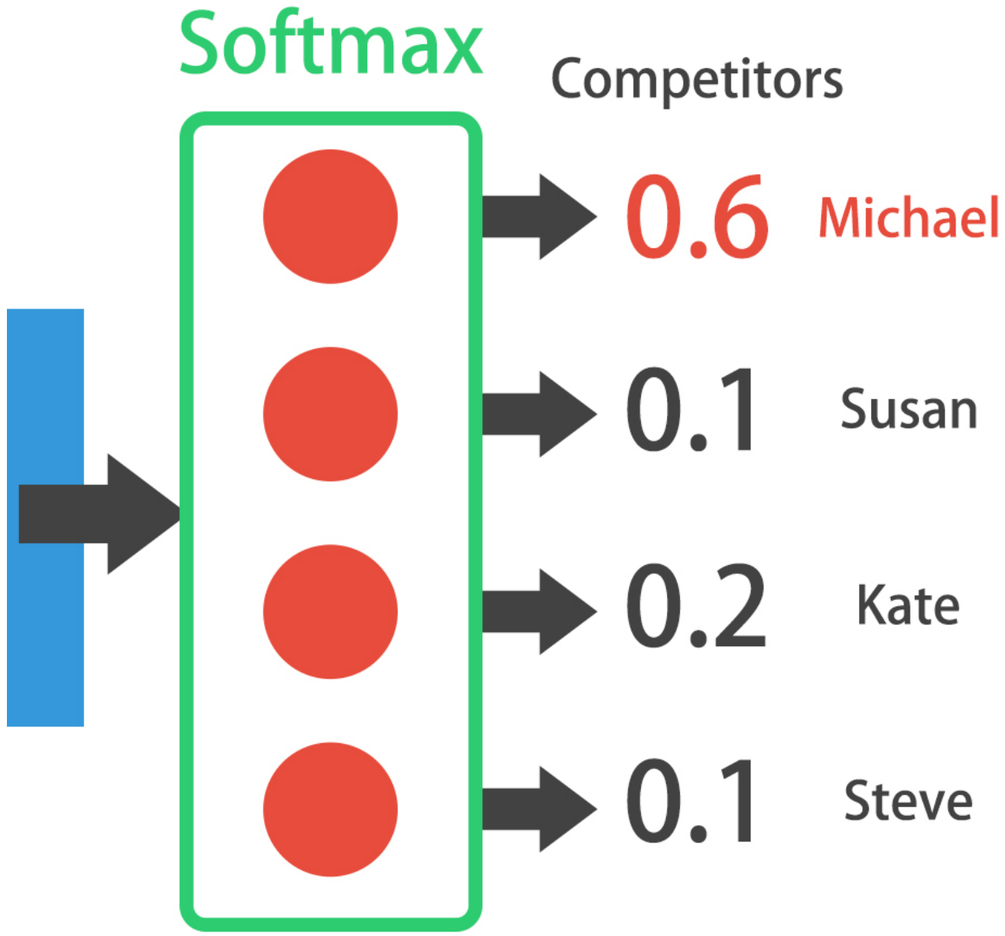
The architecture



The architecture



The output layer

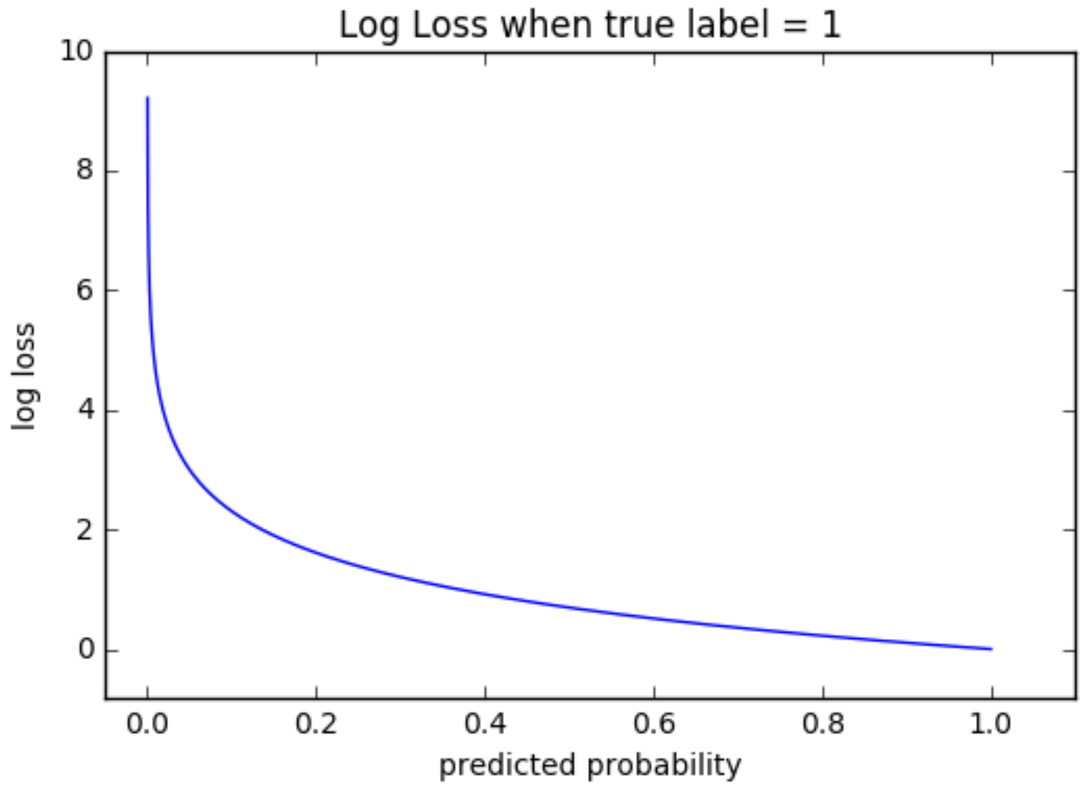


Multi-class model

```
# Instantiate a sequential model
# ...

# Add an input and hidden layer
# ...

# Add more hidden layers
# ...

# Add your output layer
model.add(Dense(4, activation='softmax')
```

Categorical cross-entropy

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



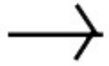
Preparing a dataset

```
import pandas as pd
from keras.utils import to_categorical


# Load dataset
df = pd.read_csv('data.csv')

# Turn response variable into labeled codes
df.response = pd.Categorical(df.response)
df.response = df.response.cat.codes

# Turn response variable into one-hot response vector
y = to_categorical(df.response)
```

One-hot encoding

Label Encoding

Food Name	Categorical #	Calories
Apple	1	95
Chicken	2	231
Broccoli	3	50



One Hot Encoding

Apple	Chicken	Broccoli	Calories
1	0	0	95
0	1	0	231
0	0	1	50

Let's practice!

INTRODUCTION TO DEEP LEARNING WITH KERAS

Multi-label classification

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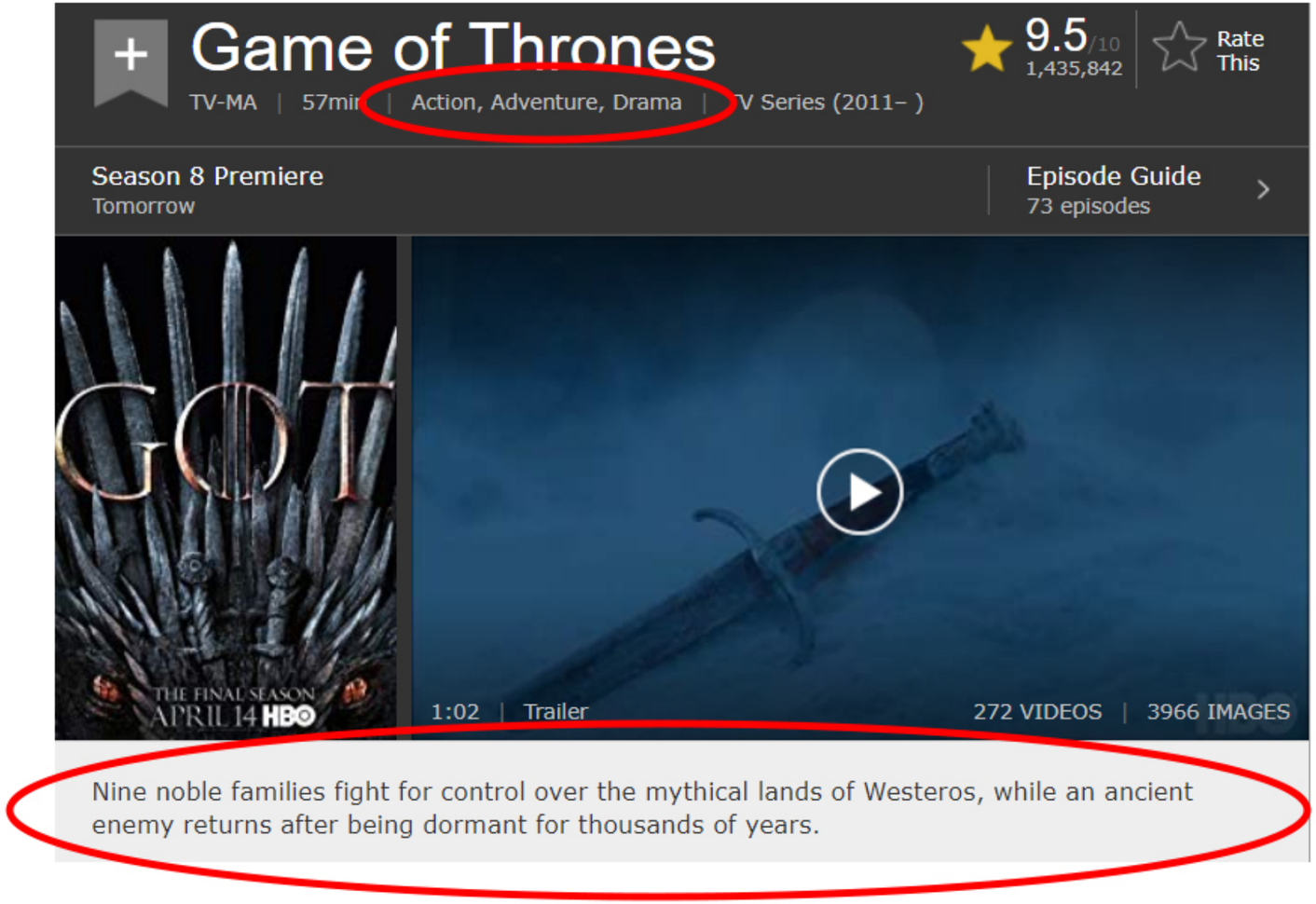
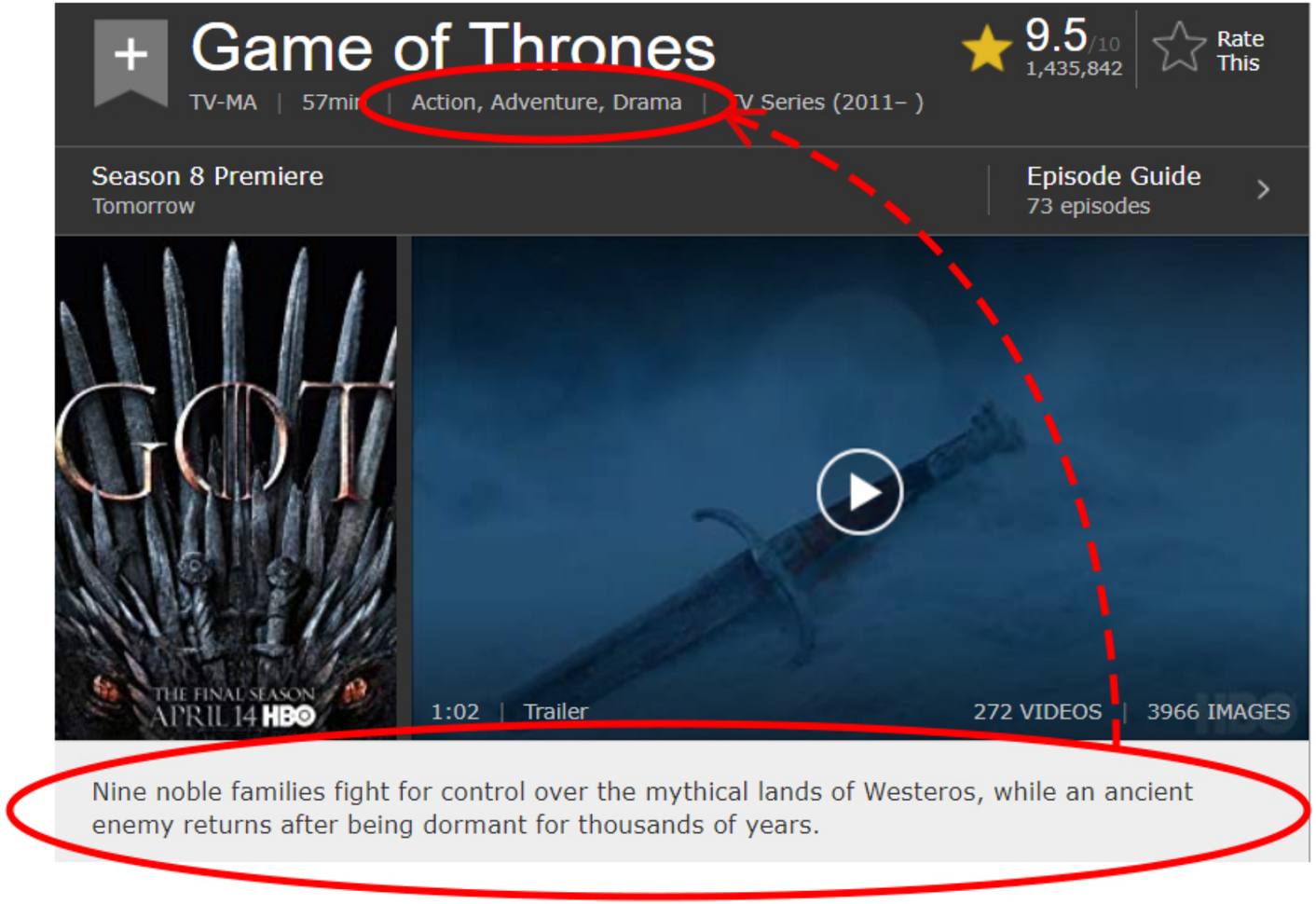
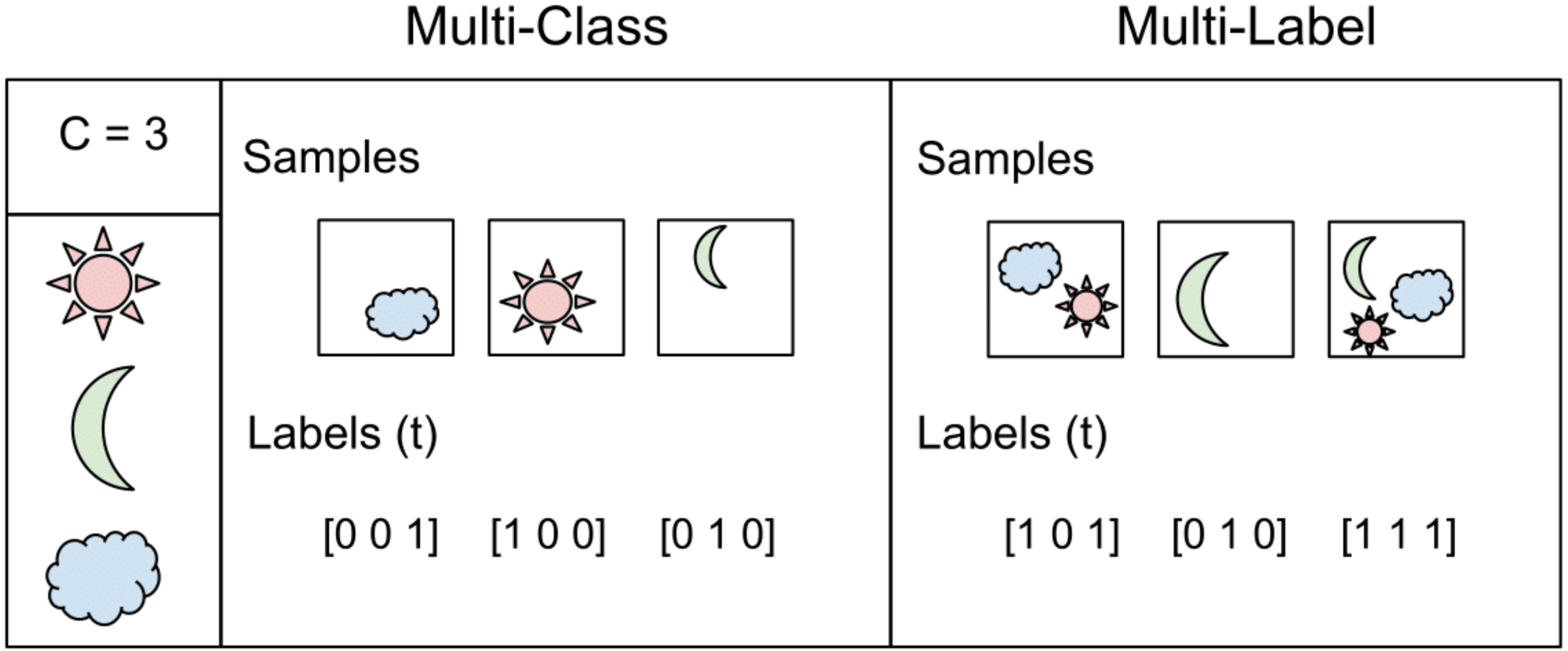
Real world examples



Real world examples





[1] https://gombru.github.io/2018/05/23/cross_entropy_loss/

The architecture

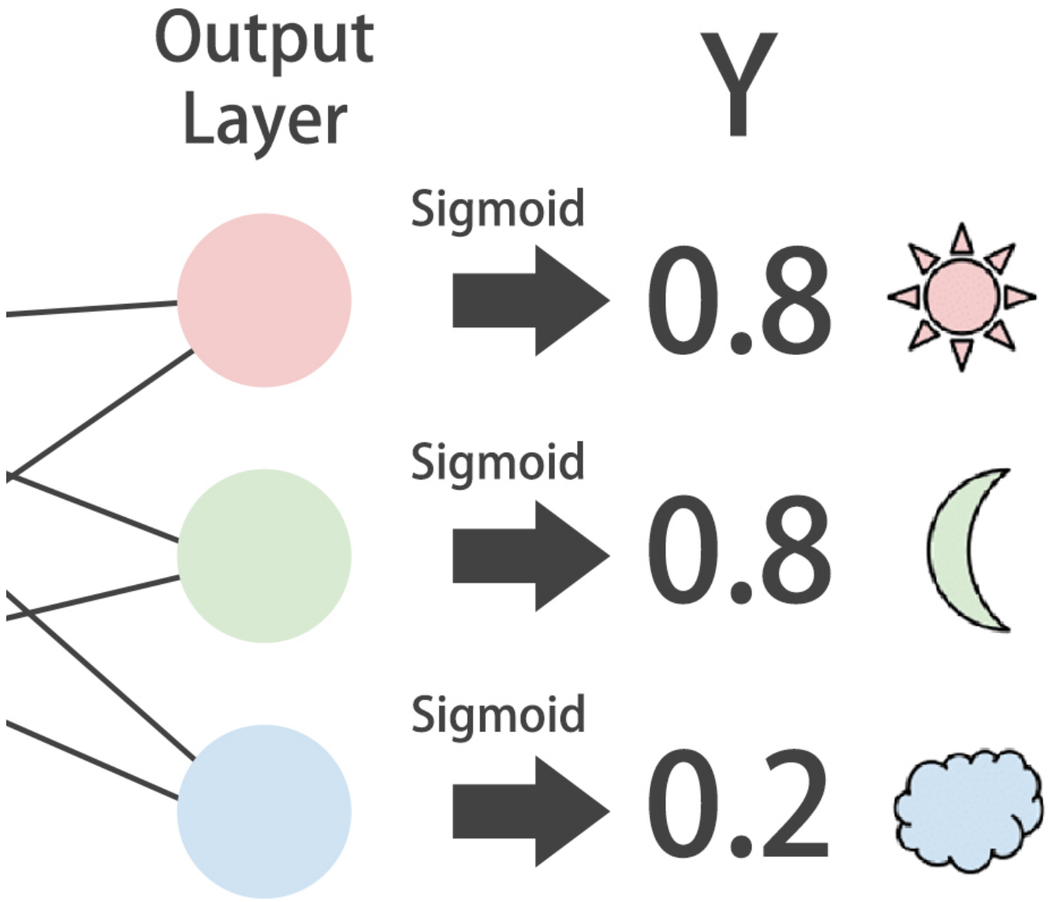
```
from keras.models import Sequential
from keras.layers import Dense


# Instantiate model
model = Sequential()

# Add input and hidden layers
model.add(Dense(2, input_shape=(1,)))

# Add an output layer for the 3 classes and sigmoid activation
model.add(Dense(3, activation='sigmoid'))
```

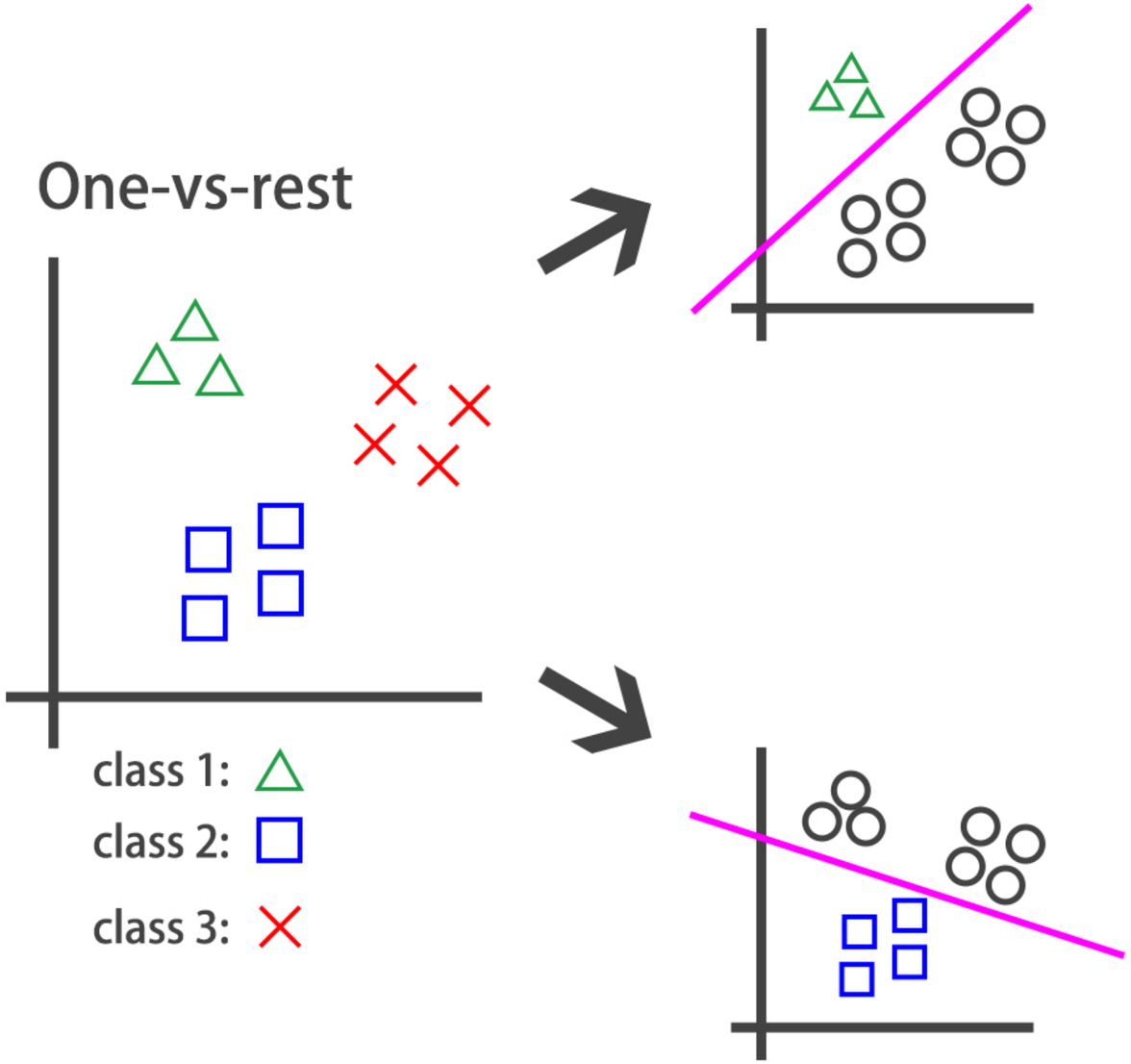
Sigmoid outputs



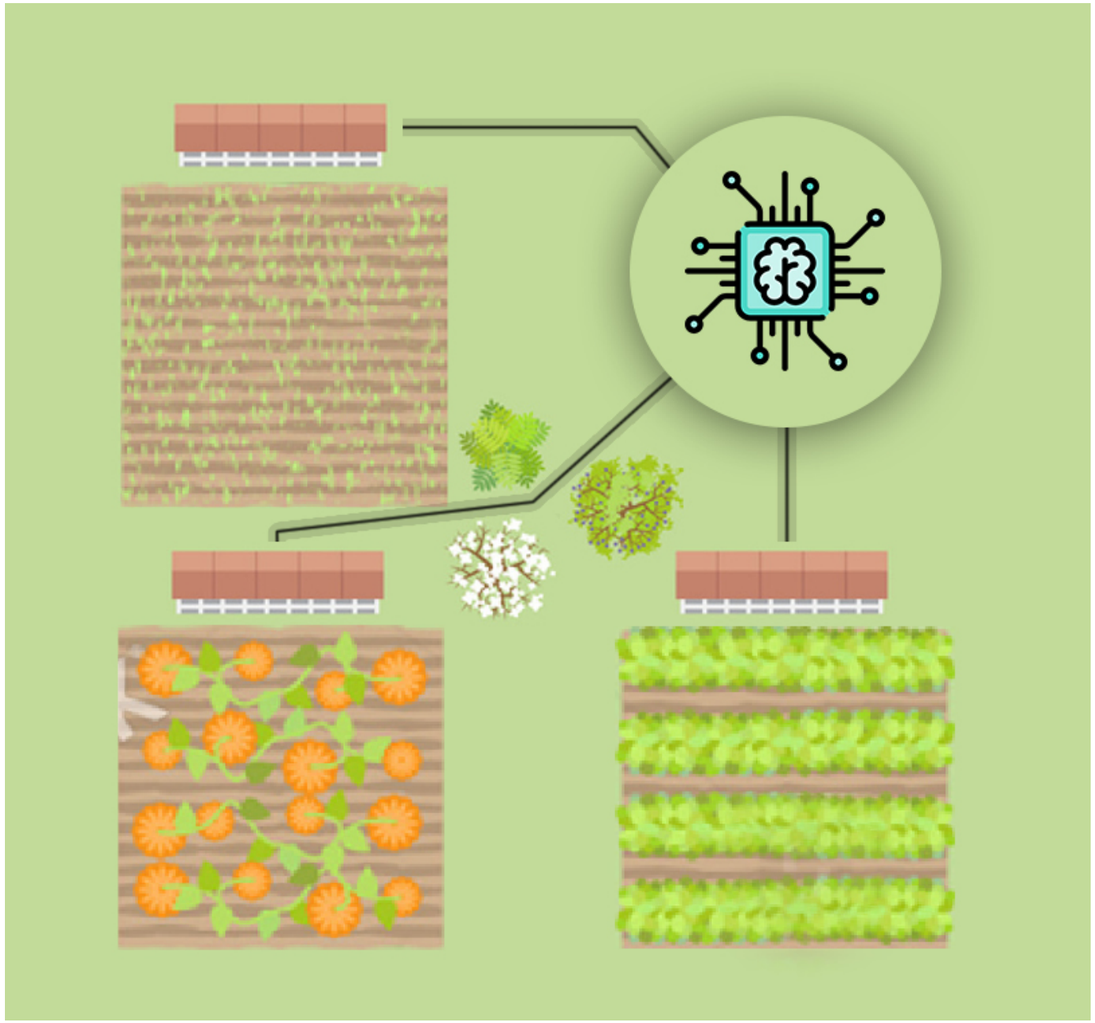
```
# Compile the model with binary crossentropy
model.compile(optimizer='adam', loss='binary_crossentropy')
```

```
# Train your model, recall validation_split
model.fit(X_train, y_train,
          epochs=100,
          validation_split=0.2)
```

```
Train on 1260 samples, validate on 280 samples
Epoch 1/100
1260/1260 [==============================] - 0s 285us/step
- loss: 0.7035 - acc: 0.6690 - val_loss: 0.5178 - val_acc: 0.7714
...
```


One-vs-rest
class 1:
class 2:
class 3:

An irrigation machine



An irrigation machine

Sensor measurements

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0	4.0	3.0	4.0	4.0	1.0	1.0	4.0	0.0	3.0	3.0	2.0	2.0	3.0	1.0	4.0	2.0	2.0	2.0	1.0	4.0
1	1.0	1.0	6.0	3.0	2.0	3.0	4.0	5.0	1.0	3.0	3.0	2.0	3.0	2.0	2.0	4.0	0.0	1.0	2.0	4.0
2	1.0	5.0	7.0	6.0	4.0	0.0	0.0	6.0	0.0	1.0	1.0	3.0	4.0	2.0	1.0	0.0	4.0	1.0	1.0	3.0
3	0.0	1.0	3.0	3.0	7.0	1.0	2.0	2.0	0.0	4.0	3.0	2.0	4.0	2.0	0.0	2.0	3.0	4.0	1.0	2.0
4	1.0	5.0	2.0	2.0	1.0	0.0	3.0	3.0	1.0	1.0	5.0	1.0	1.0	2.0	2.0	4.0	3.0	3.0	0.0	5.0

Parcels to water

	0	1	2
0	0	0	0
1	1	1	1
2	1	1	0
3	1	1	1
4	0	0	0

Let's practice!

INTRODUCTION TO DEEP LEARNING WITH KERAS

Keras callbacks

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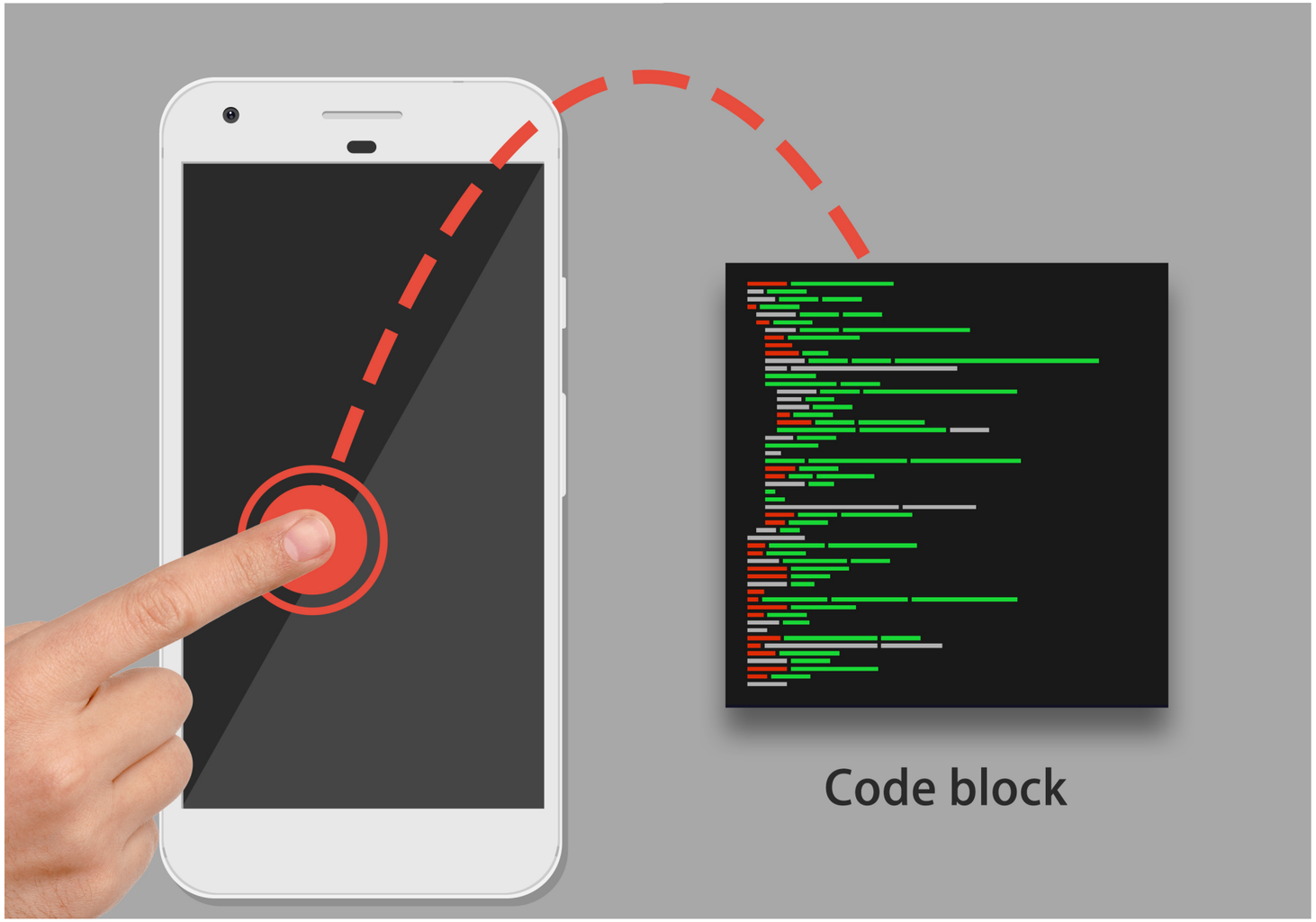
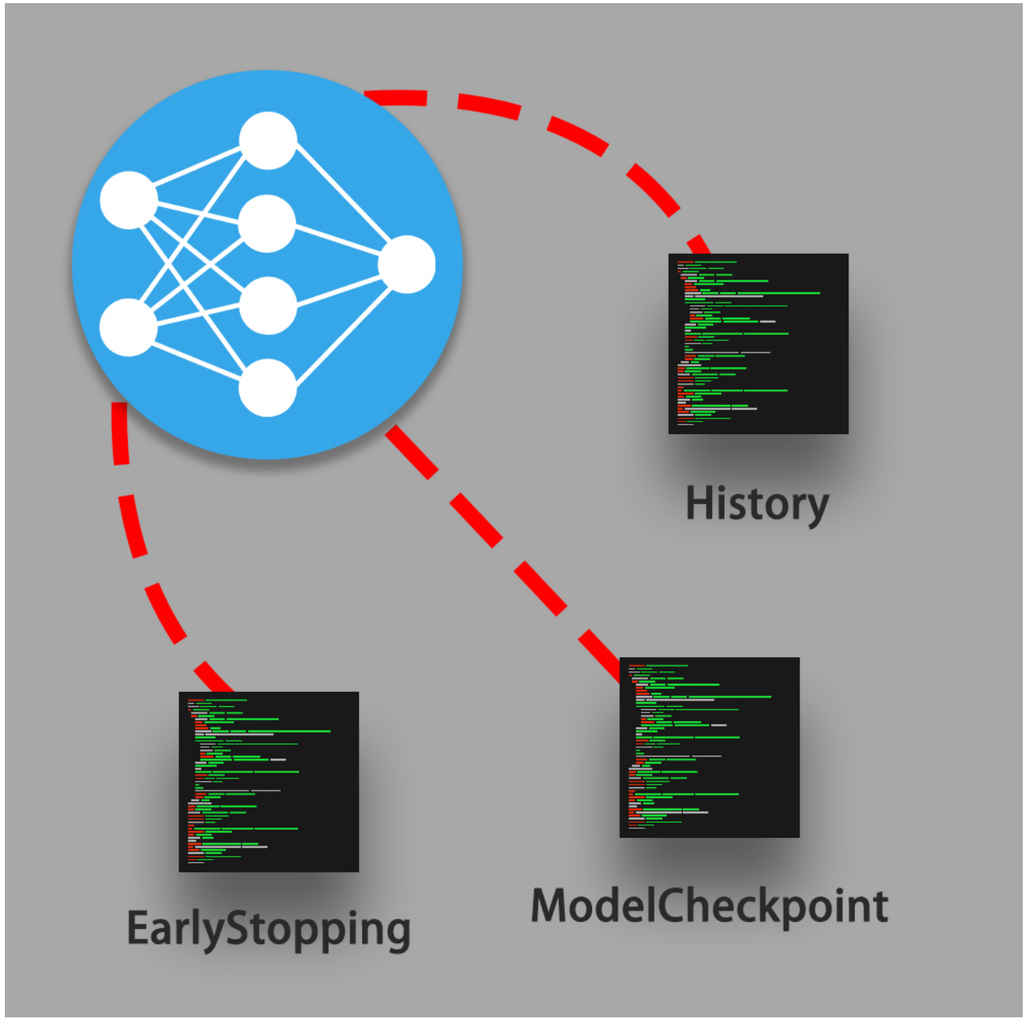
What is a callback?



Callbacks in Keras



A callback you've been missing

```
# Training a model and saving its history
history = model.fit(X_train, y_train,
                    epochs=100,
                    metrics=['accuracy'])
print(history.history['loss'])
```

```
[0.6753975939750672, ..., 0.3155936544282096]
```

```
print(history.history['acc'])
```

```
[0.7030952412741525, ..., 0.8604761900220599]
```

A callback you've been missing

```
# Training a model and saving its history
history = model.fit(X_train, y_train,
                    epochs=100,
                    validation_data=(X_test, y_test),
                    metrics=['accuracy'])
print(history.history['val_loss'])
```

```
[0.7753975939750672, ..., 0.4155936544282096]
```

```
print(history.history['val_acc'])
```

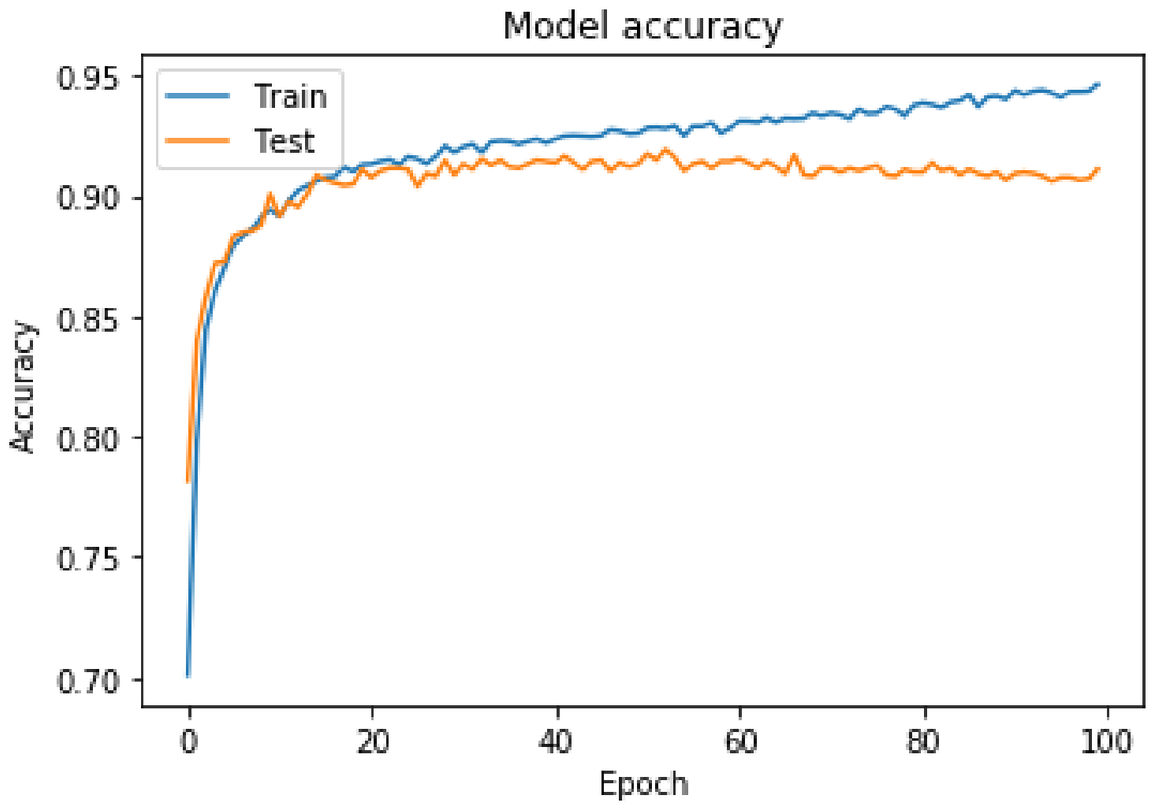
```
[0.6030952412741525, ..., 0.7604761900220599]
```

History plots

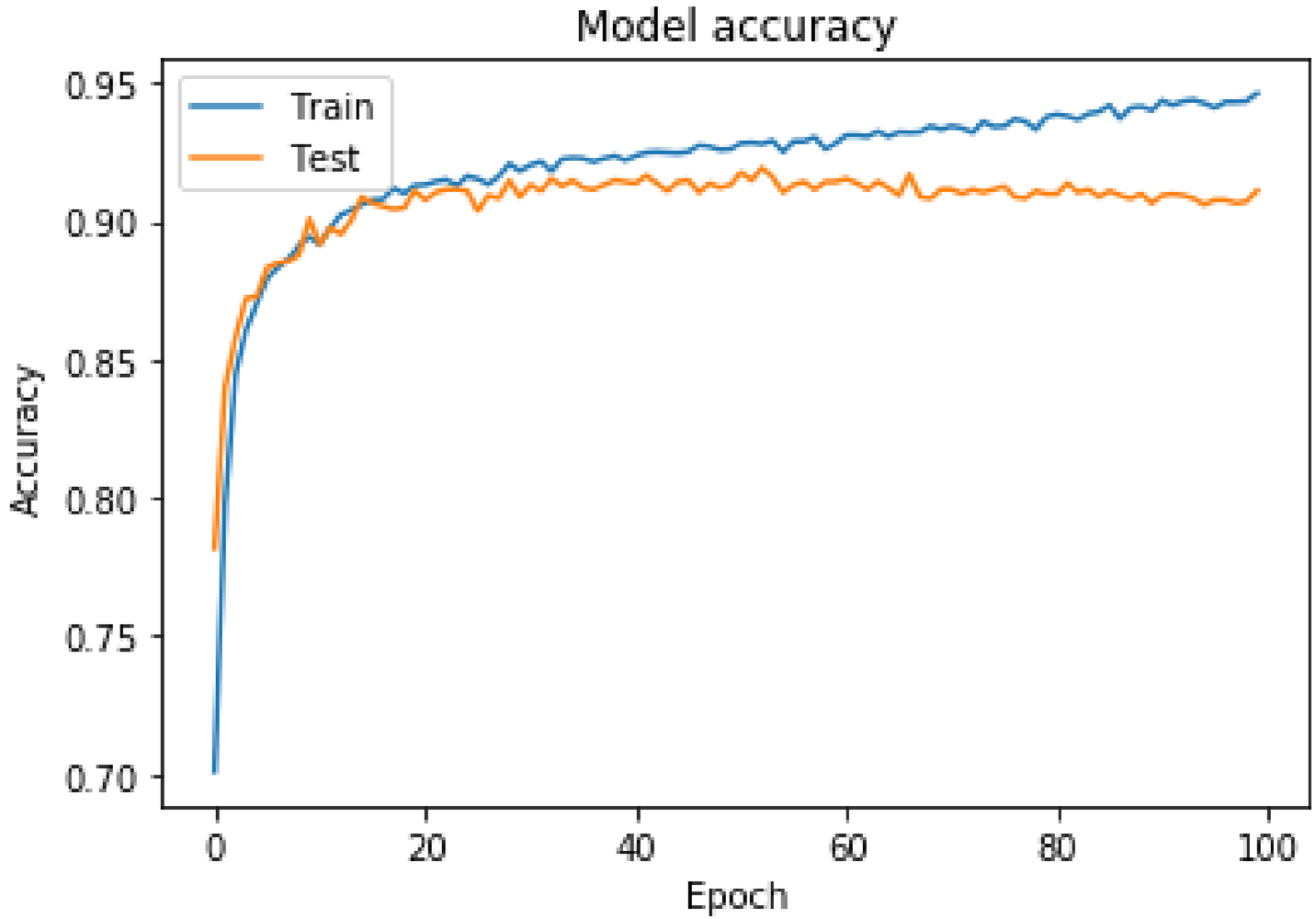
```
# Plot train vs test accuracy per epoch
plt.figure()

# Use the history metrics
plt.plot(history.history['acc'])
plt.plot(history.history['val_acc'])

# Make it pretty
plt.title('Model accuracy')
plt.ylabel('Accuracy')
plt.xlabel('Epoch')
plt.legend(['Train', 'Test'])
plt.show()
```



History plots



Early stopping

```
# Import early stopping from keras callbacks
from keras.callbacks import EarlyStopping


# Instantiate an early stopping callback
early_stopping = EarlyStopping(monitor='val_loss', patience=5)


# Train your model with the callback
model.fit(X_train, y_train, epochs=100,
          validation_data=(X_test, y_test),
          callbacks = [early_stopping])
```

Model checkpoint

```
# Import model checkpoint from keras callbacks
from keras.callbacks import ModelCheckpoint


# Instantiate a model checkpoint callback
model_save = ModelCheckpoint('best_model.hdf5',
                             save_best_only=True)


# Train your model with the callback
model.fit(X_train, y_train, epochs=100,
          validation_data=(X_test, y_test),
          callbacks = [model_save])
```

Let's practice!

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