

# 7020466-A2-Task2

March 5, 2022

## 0.0.1 CSCI 316 - A2 Individual Task 2- 28/02/2022

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- MAGIC Gamma Telescope Dataset
- Artificial Neural Network (ANN) in TensorFlow/Keras to predict the signal class.

## 0.1 1. Import Libraries

```
[1]: import matplotlib.pyplot as plt
      #import seaborn as sns

      import numpy as np # linear algebra
      import pandas as pd # data processing, CSV file I/O (e.g. pd.read_csv)
      from sklearn.model_selection import train_test_split
```

```
[2]: import tensorflow as tf
      import matplotlib.pyplot as plt

      from tensorflow import keras
      #from tensorflow.keras import Sequential
      #from tensorflow.keras import optimizers
      #from tensorflow.keras.layers import Flatten, Dense, Softmax

      import warnings
      warnings.filterwarnings("ignore")
```

Init Plugin

Init Graph Optimizer

Init Kernel

## 0.2 2. Import MAGIC Gamma Telescope Dataset

```
[3]: # Column name of each header
      colsName = ['fLength',
                  ↪ 'fWidth', 'fSize', 'fConc', 'fConc1', 'fAsym', 'fM3Long', 'fM3Trans', 'fAlpha', 'fDist', 'class']

      # Read in data from .data file
      mdf =pd.read_csv("magic04.data", names=colsName)
```

```
# Display data
mdf.head()
```

```
[3]:
```

	fLength	fWidth	fSize	fConc	fConc1	fAsym	fM3Long	fM3Trans	\
0	28.7967	16.0021	2.6449	0.3918	0.1982	27.7004	22.0110	-8.2027	
1	31.6036	11.7235	2.5185	0.5303	0.3773	26.2722	23.8238	-9.9574	
2	162.0520	136.0310	4.0612	0.0374	0.0187	116.7410	-64.8580	-45.2160	
3	23.8172	9.5728	2.3385	0.6147	0.3922	27.2107	-6.4633	-7.1513	
4	75.1362	30.9205	3.1611	0.3168	0.1832	-5.5277	28.5525	21.8393	

	fAlpha	fDist	class
0	40.0920	81.8828	g
1	6.3609	205.2610	g
2	76.9600	256.7880	g
3	10.4490	116.7370	g
4	4.6480	356.4620	g

```
[4]: # Get total rows and cols
mdf.shape
```

```
[4]: (19020, 11)
```

```
[5]: # Get discription of database
mdf.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 19020 entries, 0 to 19019
Data columns (total 11 columns):
#   Column      Non-Null Count  Dtype
---  -
0    fLength    19020 non-null  float64
1    fWidth     19020 non-null  float64
2    fSize      19020 non-null  float64
3    fConc      19020 non-null  float64
4    fConc1     19020 non-null  float64
5    fAsym      19020 non-null  float64
6    fM3Long    19020 non-null  float64
7    fM3Trans   19020 non-null  float64
8    fAlpha     19020 non-null  float64
9    fDist      19020 non-null  float64
10   class      19020 non-null  object
dtypes: float64(10), object(1)
memory usage: 1.6+ MB
```

### 0.3 3. Check for NULL, empty or zero values in dataset

```
[6]: # Check each columns for how many null data
print("Missing values for each column:\n")
print(mdf.isnull().any())
```

Missing values for each column:

```
fLength      False
fWidth       False
fSize        False
fConc        False
fConc1       False
fAsym        False
fM3Long      False
fM3Trans     False
fAlpha       False
fDist        False
class        False
dtype: bool
```

```
[7]: # Check each columns for how many null data
print("Missing values for each column:\n")
print(mdf.isnull().sum())
```

Missing values for each column:

```
fLength      0
fWidth       0
fSize        0
fConc        0
fConc1       0
fAsym        0
fM3Long      0
fM3Trans     0
fAlpha       0
fDist        0
class        0
dtype: int64
```

- No null value is present

```
[8]: # Check number of non-zeros in each column
mdf.astype(bool).sum(axis=0)
```

```
[8]: fLength      19020
fWidth      18922
fSize       19020
```

```
fConc      19020
fConc1     19020
fAsym      18979
fM3Long    18981
fM3Trans   18961
fAlpha     19015
fDist      19020
class      19020
dtype: int64
```

- Columns fWidth, fAsym, fM3Long, fM3Trans, fAlpha has values that contains 0

### 0.3.1 Replace 0 values with mean

```
[9]: # Replace 0 values with mean
mdf['fWidth'] = mdf['fWidth'].replace(0, mdf['fWidth'].mean())
mdf['fAsym'] = mdf['fAsym'].replace(0, mdf['fAsym'].mean())
mdf['fM3Long'] = mdf['fM3Long'].replace(0, mdf['fM3Long'].mean())
mdf['fM3Trans'] = mdf['fM3Trans'].replace(0, mdf['fM3Trans'].mean())
mdf['fAlpha'] = mdf['fAlpha'].replace(0, mdf['fAlpha'].mean())
```

```
[10]: # Check number of non-zeros in each column
mdf.astype(bool).sum(axis=0)
```

```
[10]: fLength      19020
fWidth      19020
fSize       19020
fConc       19020
fConc1      19020
fAsym       19020
fM3Long     19020
fM3Trans    19020
fAlpha      19020
fDist       19020
class       19020
dtype: int64
```

- No more 0 values in mdf database

```
[11]: # Check if all data is in order
mdf.head()
```

```
[11]:   fLength  fWidth  fSize  fConc  fConc1  fAsym  fM3Long  fM3Trans  \
0   28.7967  16.0021  2.6449  0.3918  0.1982  27.7004  22.0110  -8.2027
1   31.6036  11.7235  2.5185  0.5303  0.3773  26.2722  23.8238  -9.9574
2  162.0520 136.0310  4.0612  0.0374  0.0187 116.7410 -64.8580 -45.2160
3   23.8172   9.5728  2.3385  0.6147  0.3922  27.2107  -6.4633  -7.1513
4   75.1362  30.9205  3.1611  0.3168  0.1832  -5.5277  28.5525  21.8393
```

	fAlpha	fDist	class
0	40.0920	81.8828	g
1	6.3609	205.2610	g
2	76.9600	256.7880	g
3	10.4490	116.7370	g
4	4.6480	356.4620	g

#### 0.4 4. Encode Column 'class' To dtype int64

```
[12]: # show the total number of each cover types in this dataframe
mdf.groupby('class').size()
```

```
[12]: class
g      12332
h       6688
dtype: int64
```

```
[13]: # Encode Sex column
encode_data = {"class":{"g":1, "h":2}}
mdf = mdf.replace(encode_data)
mdf
```

```
[13]:
```

	fLength	fWidth	fSize	fConc	fConc1	fAsym	fM3Long	\
0	28.7967	16.0021	2.6449	0.3918	0.1982	27.7004	22.0110	
1	31.6036	11.7235	2.5185	0.5303	0.3773	26.2722	23.8238	
2	162.0520	136.0310	4.0612	0.0374	0.0187	116.7410	-64.8580	
3	23.8172	9.5728	2.3385	0.6147	0.3922	27.2107	-6.4633	
4	75.1362	30.9205	3.1611	0.3168	0.1832	-5.5277	28.5525	
...	...	...	...	...	...	...	...	
19015	21.3846	10.9170	2.6161	0.5857	0.3934	15.2618	11.5245	
19016	28.9452	6.7020	2.2672	0.5351	0.2784	37.0816	13.1853	
19017	75.4455	47.5305	3.4483	0.1417	0.0549	-9.3561	41.0562	
19018	120.5135	76.9018	3.9939	0.0944	0.0683	5.8043	-93.5224	
19019	187.1814	53.0014	3.2093	0.2876	0.1539	-167.3125	-168.4558	

	fM3Trans	fAlpha	fDist	class
0	-8.2027	40.0920	81.8828	1
1	-9.9574	6.3609	205.2610	1
2	-45.2160	76.9600	256.7880	1
3	-7.1513	10.4490	116.7370	1
4	21.8393	4.6480	356.4620	1
...	...	...	...	...
19015	2.8766	2.4229	106.8258	2
19016	-2.9632	86.7975	247.4560	2
19017	-9.4662	30.2987	256.5166	2
19018	-63.8389	84.6874	408.3166	2

```
19019    31.4755  52.7310  272.3174         2
```

```
[19020 rows x 11 columns]
```

```
[14]: # Check if all columns are  
mdf.info()
```

```
<class 'pandas.core.frame.DataFrame'>  
RangeIndex: 19020 entries, 0 to 19019  
Data columns (total 11 columns):  
#   Column      Non-Null Count  Dtype  
---  -  
0   fLength     19020 non-null   float64  
1   fWidth      19020 non-null   float64  
2   fSize       19020 non-null   float64  
3   fConc       19020 non-null   float64  
4   fConc1      19020 non-null   float64  
5   fAsym       19020 non-null   float64  
6   fM3Long     19020 non-null   float64  
7   fM3Trans    19020 non-null   float64  
8   fAlpha      19020 non-null   float64  
9   fDist       19020 non-null   float64  
10  class       19020 non-null   int64  
dtypes: float64(10), int64(1)  
memory usage: 1.6 MB
```

## 0.5 5. Split Data Into 70% Training & 30% Test

```
[15]: # Set features and target  
# X stores everything else except 'class', Y stores 'class'  
X, y = mdf.iloc[:, :-1], mdf.iloc[:, -1]  
  
X = X.to_numpy()  
y = y.to_numpy()  
  
# Randomize data  
arr_rand = np.random.rand(X.shape[0]) # Pass in all cols except last  
split = arr_rand < np.percentile(arr_rand, 70) # split by 30/70  
  
# Declare x & y train, test  
X_train = X[split]  
y_train = y[split]  
  
X_test = X[~split]  
y_test = y[~split]  
  
# Print data in X and y train/test
```

```
print("X_train y_train: ",X_train.shape, y_train.shape)
print("X_test y_test: ", X_test.shape, y_test.shape)
```

```
X_train y_train: (13314, 10) (13314,)
X_test y_test: (5706, 10) (5706,)
```

## 0.6 6. Performing Feature Scaling

- convert all the variables to the same scale
- balance very high values even when there's certain variables have very low values.
- prevent low value from being neglected by our model.
- import to scale after splitting as perform feature scaling before the splitting will cause information leakage.
- StandardScaler convert values ranging between -3 to +3.

```
[16]: # Removes mean & scales the data to unit variance.
from sklearn.pipeline import make_pipeline
from sklearn.linear_model import LogisticRegression
from sklearn.preprocessing import StandardScaler

sc = make_pipeline(StandardScaler(), LogisticRegression())
sc.fit(X_train, y_train)
print(sc.score(X_test, y_test))

#X_train = sc.fit_transform(X_train)
#X_test = sc.fit_transform(X_test)
#print(X_train)
#print(sc.fit(X_train, y_train))
```

```
0.7793550648440238
```

## 0.7 7. Initialize Artificial Neural Network (ANN)

- Sequential( ) ANN Model

```
[17]: # Import libraries
from keras.constraints import maxnorm
from keras.wrappers.scikit_learn import KerasClassifier
from sklearn.model_selection import GridSearchCV
from keras.models import Sequential
from keras.layers import Dense

from tensorflow.keras.optimizers import SGD
```

```
[18]: # Function to create model, required for KerasClassifier
def ann_model(neurons=11,
              weight_constraint=5,activation='relu',
              init_mode='normal',optimizer='adam',
              learn_rate=0.1, momentum=0.6):
```

```

#Initialising Sequential
model = Sequential()

#for _ in range(n_hidden):
# Adding First Hidden Layer
model.add(Dense(neurons,
                 kernel_initializer=init_mode,
                 input_dim = X_train.shape[1],
                 activation=activation,
                 #kernel_constraint=maxnorm(weight_constraint)
                 ))

# Adding Second Hidden Layer
model.add(Dense(neurons, activation=activation))

# Adding Output Layer
model.add(Dense(1, activation= activation))

# Xompile the keras model
#optimizer = SGD(lr=learn_rate, momentum=momentum)
model.compile(loss='binary_crossentropy', optimizer=optimizer,
↳metrics=['accuracy'])

return model

# Create Keras model
model = KerasClassifier(build_fn=ann_model, epochs=20, verbose=2)
model

```

[18]: <keras.wrappers.scikit\_learn.KerasClassifier at 0x16e5700a0>

```

[19]: #Fit the model w X_train & y_train
history1 = model.fit(X_train,
                    y_train,
                    validation_data = (X_test, y_test))

```

Metal device set to: Apple M1 Pro

Epoch 1/20

```

2022-03-05 13:19:47.663234: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.
2022-03-05 13:19:47.663360: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0
MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:

```



```

<undefined>)
2022-03-05 13:19:47.792495: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:176] None of the MLIR
Optimization Passes are enabled (registered 2)
2022-03-05 13:19:47.792675: W
tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU
frequency: 0 Hz
2022-03-05 13:19:54.080925: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:19:56.189422: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

417/417 - 9s - loss: 3.0034 - accuracy: 0.6368 - val_loss: 0.3064 -
val_accuracy: 0.0398
Epoch 2/20
417/417 - 2s - loss: 0.5444 - accuracy: 0.7738 - val_loss: 0.8537 -
val_accuracy: 0.0384
Epoch 3/20
417/417 - 2s - loss: 0.5261 - accuracy: 0.7860 - val_loss: 0.2943 -
val_accuracy: 0.0734
Epoch 4/20
417/417 - 2s - loss: 0.5094 - accuracy: 0.7898 - val_loss: 0.1909 -
val_accuracy: 0.0832
Epoch 5/20
417/417 - 2s - loss: 0.4931 - accuracy: 0.7977 - val_loss: 0.6678 -
val_accuracy: 0.0435
Epoch 6/20
417/417 - 2s - loss: 0.4701 - accuracy: 0.8007 - val_loss: 0.3543 -
val_accuracy: 0.0606
Epoch 7/20
417/417 - 2s - loss: 0.4606 - accuracy: 0.8110 - val_loss: 0.3282 -
val_accuracy: 0.0356
Epoch 8/20
417/417 - 2s - loss: 0.4644 - accuracy: 0.8085 - val_loss: -1.9695e-01 -
val_accuracy: 0.0566
Epoch 9/20
417/417 - 2s - loss: 0.5402 - accuracy: 0.7898 - val_loss: -9.2818e-02 -
val_accuracy: 0.0999
Epoch 10/20
417/417 - 2s - loss: 0.4931 - accuracy: 0.7895 - val_loss: 0.2048 -
val_accuracy: 0.0727
Epoch 11/20
417/417 - 2s - loss: 0.4824 - accuracy: 0.8031 - val_loss: 0.5774 -
val_accuracy: 0.0622
Epoch 12/20
417/417 - 2s - loss: 0.4856 - accuracy: 0.8017 - val_loss: 0.5819 -

```

```

val_accuracy: 0.0498
Epoch 13/20
417/417 - 2s - loss: 0.4752 - accuracy: 0.8065 - val_loss: 0.1879 -
val_accuracy: 0.0866
Epoch 14/20
417/417 - 2s - loss: 0.4650 - accuracy: 0.8039 - val_loss: 0.2365 -
val_accuracy: 0.0761
Epoch 15/20
417/417 - 2s - loss: 0.6742 - accuracy: 0.7555 - val_loss: 2.3063 -
val_accuracy: 8.7627e-04
Epoch 16/20
417/417 - 2s - loss: 0.6894 - accuracy: 0.7028 - val_loss: 0.9009 -
val_accuracy: 0.0135
Epoch 17/20
417/417 - 2s - loss: 0.6170 - accuracy: 0.7390 - val_loss: 1.1421 -
val_accuracy: 0.0503
Epoch 18/20
417/417 - 2s - loss: 0.5808 - accuracy: 0.7807 - val_loss: -5.3283e-02 -
val_accuracy: 0.0461
Epoch 19/20
417/417 - 2s - loss: 0.5244 - accuracy: 0.7964 - val_loss: 0.6596 -
val_accuracy: 0.0310
Epoch 20/20
417/417 - 2s - loss: 0.5165 - accuracy: 0.7902 - val_loss: -1.0510e-02 -
val_accuracy: 0.0542

```

### Display Model Summary

```

[20]: # Evaluate the keras model
a=ann_model()
a.summary()

```

Model: "sequential\_1"

Layer (type)	Output Shape	Param #
dense_3 (Dense)	(None, 11)	121
dense_4 (Dense)	(None, 11)	132
dense_5 (Dense)	(None, 1)	12

Total params: 265  
 Trainable params: 265  
 Non-trainable params: 0

### Prediction

```
[21]: # Predict
pred_test = model.predict(X_test)
print("Mean sq. error between y_test & predicted =", np.
      ↪mean(pred_test-y_test)**2)
```

179/179 - 0s

2022-03-05 13:20:40.808694: I

tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]

Plugin optimizer for device\_type GPU is enabled.

Mean sq. error between y\_test & predicted = 0.01036785059331474

### Report Learning Curve

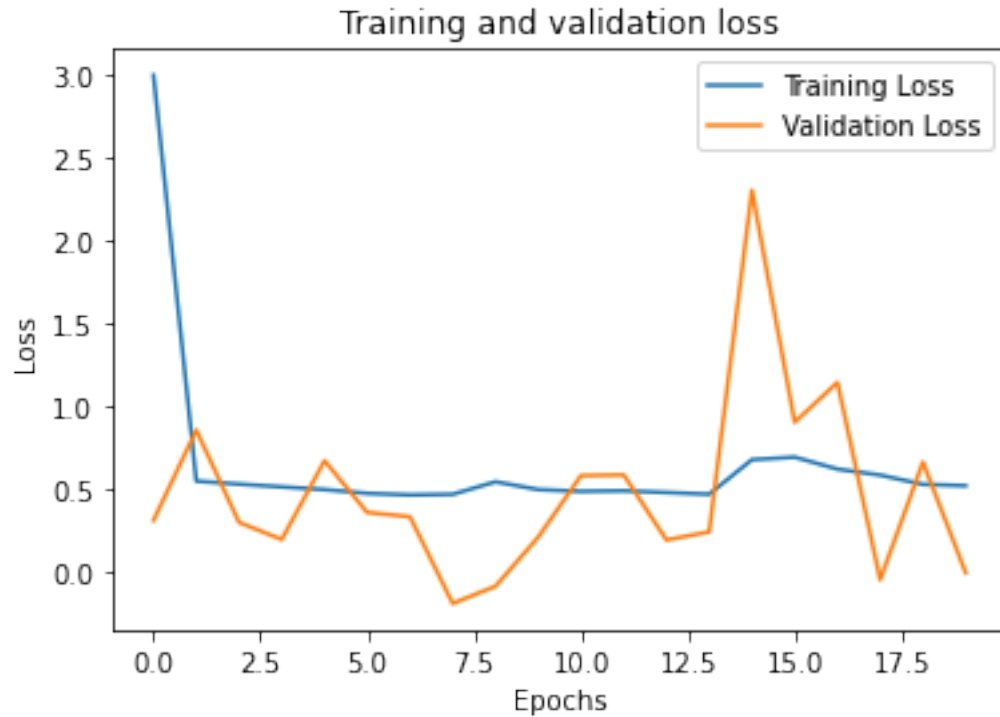
```
[22]: #plot the training and validation accuracy and loss at each epoch
print(history1.history.keys())

# plot metrics
plt.title('Training and validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')

plt.plot(history1.history['loss'])
plt.plot(history1.history['val_loss'])
#plt.plot(history2.history['mse'])
#plt.plot(history2.history['val_loss'])
#plt.plot(history.history['val_mse'])
#plt.plot(history.history['val_mae'])

plt.legend(['Training Loss', 'Validation Loss'], loc='upper right')
plt.show()
```

```
dict_keys(['loss', 'accuracy', 'val_loss', 'val_accuracy'])
```



## 0.8 8. Tune using Grid Search Hyperparameters

### Tune Batch Size and Number of Epochs

```
[27]: batch_size = [10, 15]
epochs = [10, 30]
param_grid = dict(batch_size=batch_size, epochs=epochs)
grid = GridSearchCV(estimator=model, param_grid=param_grid, n_jobs=-1, cv=3)
grid_result = grid.fit(X_train, y_train)
```

```
Init Plugin
Init Graph Optimizer
Init Kernel
Init Plugin
Init Graph Optimizer
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```

Init Graph Optimizer
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Init Graph Optimizer
Init Kernel
Init Plugin
Init Graph Optimizer
Init Kernel
Metal device set to: Apple M1 Pro

2022-03-05 13:41:43.190424: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.
2022-03-05 13:41:43.190561: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0
MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:
<undefined>)
2022-03-05 13:41:43.253464: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.
2022-03-05 13:41:43.253613: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0
MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:
<undefined>)
2022-03-05 13:41:43.272405: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.
2022-03-05 13:41:43.272406: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.
2022-03-05 13:41:43.272589: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0

```

```

MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:
<undefined>)
2022-03-05 13:41:43.272595: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0
MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:
<undefined>)
2022-03-05 13:41:43.293861: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.
2022-03-05 13:41:43.293981: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0
MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:
<undefined>)
2022-03-05 13:41:43.294274: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.
2022-03-05 13:41:43.294386: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0
MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:
<undefined>)
2022-03-05 13:41:43.299533: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.
2022-03-05 13:41:43.300936: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0
MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:
<undefined>)
2022-03-05 13:41:43.321770: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.
2022-03-05 13:41:43.321816: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.
2022-03-05 13:41:43.321919: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0
MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:
<undefined>)
2022-03-05 13:41:43.321955: I

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tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0
MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:
<undefined>)
2022-03-05 13:41:43.342234: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.
2022-03-05 13:41:43.342429: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0
MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:
<undefined>)

Metal device set to: Apple M1 Pro
Metal device set to: Apple M1 Pro
Metal device set to: Apple M1 Pro
Metal device set to: Apple M1 Pro
Metal device set to: Apple M1 Pro
Metal device set to: Apple M1 Pro
Metal device set to: Apple M1 Pro
Metal device set to: Apple M1 Pro
Metal device set to: Apple M1 Pro
Metal device set to: Apple M1 Pro

2022-03-05 13:41:43.676929: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:176] None of the MLIR
Optimization Passes are enabled (registered 2)
2022-03-05 13:41:43.677348: W
tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU
frequency: 0 Hz
2022-03-05 13:41:43.680020: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:176] None of the MLIR
Optimization Passes are enabled (registered 2)
2022-03-05 13:41:43.680239: W
tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU
frequency: 0 Hz
2022-03-05 13:41:43.687553: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:176] None of the MLIR
Optimization Passes are enabled (registered 2)
2022-03-05 13:41:43.687728: W
tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU
frequency: 0 Hz
2022-03-05 13:41:43.696592: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:176] None of the MLIR
Optimization Passes are enabled (registered 2)
2022-03-05 13:41:43.696789: W
tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU
frequency: 0 Hz
2022-03-05 13:41:43.697093: I

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tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:176] None of the MLIR
Optimization Passes are enabled (registered 2)
2022-03-05 13:41:43.697252: W
tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU
frequency: 0 Hz
2022-03-05 13:41:43.700529: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:176] None of the MLIR
Optimization Passes are enabled (registered 2)
2022-03-05 13:41:43.700846: W
tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU
frequency: 0 Hz
2022-03-05 13:41:43.703296: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:176] None of the MLIR
Optimization Passes are enabled (registered 2)
2022-03-05 13:41:43.703899: W
tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU
frequency: 0 Hz
2022-03-05 13:41:43.710174: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:176] None of the MLIR
Optimization Passes are enabled (registered 2)
2022-03-05 13:41:43.710332: W
tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU
frequency: 0 Hz
2022-03-05 13:41:43.721482: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:176] None of the MLIR
Optimization Passes are enabled (registered 2)
2022-03-05 13:41:43.721669: W
tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU
frequency: 0 Hz
2022-03-05 13:41:43.726405: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:176] None of the MLIR
Optimization Passes are enabled (registered 2)
2022-03-05 13:41:43.726861: W
tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU
frequency: 0 Hz
2022-03-05 13:41:51.984068: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:41:51.985349: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:41:52.046797: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:41:52.087217: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:41:52.130915: I

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tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:41:52.139594: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:41:52.197692: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:41:52.376250: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:41:52.393236: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:41:52.462341: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 1/30
592/592 - 20s - loss: 7.2876 - accuracy: 0.5214
Epoch 1/10
592/592 - 20s - loss: 4.6410 - accuracy: 0.6466
Epoch 1/10
592/592 - 21s - loss: 0.3319 - accuracy: 0.9785
Epoch 1/10
592/592 - 21s - loss: 7.2965 - accuracy: 0.5215
Epoch 1/30
888/888 - 26s - loss: 7.3507 - accuracy: 0.5178
Epoch 1/10
888/888 - 26s - loss: 0.3452 - accuracy: 0.9770
Epoch 1/30
888/888 - 26s - loss: 1.6369 - accuracy: 0.7054
Epoch 1/10
888/888 - 26s - loss: 7.2965 - accuracy: 0.5215
Epoch 1/30
888/888 - 26s - loss: 12.5209 - accuracy: 0.1750
Epoch 1/10
888/888 - 27s - loss: 2.9717 - accuracy: 0.6701
Epoch 2/30
592/592 - 12s - loss: 7.2965 - accuracy: 0.5215
Epoch 2/10
592/592 - 12s - loss: 3.9189 - accuracy: 0.7058
Epoch 2/10
592/592 - 12s - loss: 0.3319 - accuracy: 0.9785
Epoch 2/10
592/592 - 12s - loss: 7.2965 - accuracy: 0.5215
Epoch 2/30
888/888 - 18s - loss: 7.3070 - accuracy: 0.5207

```

Epoch 3/30  
592/592 - 12s - loss: 7.2965 - accuracy: 0.5215  
Epoch 2/30  
888/888 - 18s - loss: 1.1643 - accuracy: 0.7331  
Epoch 2/10  
888/888 - 18s - loss: 0.3319 - accuracy: 0.9785  
Epoch 3/10  
592/592 - 12s - loss: 5.0362 - accuracy: 0.6398  
Epoch 2/10  
888/888 - 18s - loss: 7.2965 - accuracy: 0.5215  
Epoch 2/30  
888/888 - 18s - loss: 0.3319 - accuracy: 0.9785  
Epoch 3/10  
592/592 - 12s - loss: 0.3319 - accuracy: 0.9785  
Epoch 3/10  
592/592 - 11s - loss: 7.2965 - accuracy: 0.5215  
Epoch 2/10  
888/888 - 18s - loss: 0.6998 - accuracy: 0.6740  
Epoch 4/30  
592/592 - 11s - loss: 7.2965 - accuracy: 0.5215  
Epoch 4/10  
592/592 - 12s - loss: 4.4967 - accuracy: 0.6761  
Epoch 4/10  
592/592 - 12s - loss: 0.3319 - accuracy: 0.9785  
Epoch 4/10  
592/592 - 12s - loss: 7.2965 - accuracy: 0.5215  
Epoch 3/30  
888/888 - 17s - loss: 7.3002 - accuracy: 0.5212  
Epoch 3/30  
888/888 - 17s - loss: 0.5197 - accuracy: 0.7756  
Epoch 3/10  
888/888 - 17s - loss: 0.3319 - accuracy: 0.9785  
Epoch 3/10  
888/888 - 18s - loss: 7.2965 - accuracy: 0.5215  
Epoch 3/30  
888/888 - 17s - loss: 0.3319 - accuracy: 0.9785  
Epoch 3/10  
888/888 - 17s - loss: 0.6574 - accuracy: 0.7089  
Epoch 5/30  
592/592 - 12s - loss: 7.2965 - accuracy: 0.5215  
Epoch 5/10  
592/592 - 11s - loss: 4.5193 - accuracy: 0.6732  
Epoch 5/10  
592/592 - 12s - loss: 0.3319 - accuracy: 0.9785  
Epoch 5/10  
592/592 - 11s - loss: 7.2965 - accuracy: 0.5215  
Epoch 4/30  
888/888 - 17s - loss: 7.2999 - accuracy: 0.5213

Epoch 4/10  
888/888 - 17s - loss: 0.3319 - accuracy: 0.9785  
Epoch 6/30  
592/592 - 12s - loss: 7.2965 - accuracy: 0.5215  
Epoch 4/30  
888/888 - 17s - loss: 0.6929 - accuracy: 0.7706  
Epoch 6/10  
592/592 - 12s - loss: 4.0799 - accuracy: 0.7093  
Epoch 4/30  
888/888 - 17s - loss: 0.3319 - accuracy: 0.9785  
Epoch 4/10  
888/888 - 18s - loss: 7.2965 - accuracy: 0.5215  
Epoch 6/10  
592/592 - 12s - loss: 0.3319 - accuracy: 0.9785  
Epoch 4/10  
888/888 - 17s - loss: 0.6041 - accuracy: 0.7325  
Epoch 6/10  
592/592 - 12s - loss: 7.2965 - accuracy: 0.5215  
Epoch 7/30  
592/592 - 11s - loss: 7.2965 - accuracy: 0.5215  
Epoch 7/10  
592/592 - 12s - loss: 3.5637 - accuracy: 0.7351  
Epoch 7/10  
592/592 - 12s - loss: 0.3319 - accuracy: 0.9785  
Epoch 7/10  
592/592 - 11s - loss: 7.2965 - accuracy: 0.5215  
Epoch 5/30  
888/888 - 17s - loss: 7.2999 - accuracy: 0.5213  
Epoch 5/10  
888/888 - 17s - loss: 0.3319 - accuracy: 0.9785  
Epoch 5/30  
888/888 - 17s - loss: 0.6195 - accuracy: 0.7307  
Epoch 5/10  
888/888 - 18s - loss: 7.2965 - accuracy: 0.5215  
Epoch 5/30  
888/888 - 18s - loss: 0.3319 - accuracy: 0.9785  
Epoch 5/10  
888/888 - 17s - loss: 0.5719 - accuracy: 0.7465  
Epoch 8/30  
592/592 - 12s - loss: 7.2965 - accuracy: 0.5215  
Epoch 8/10  
592/592 - 12s - loss: 3.3482 - accuracy: 0.7373  
Epoch 8/10  
592/592 - 11s - loss: 7.2965 - accuracy: 0.5215  
Epoch 8/10  
592/592 - 12s - loss: 0.3319 - accuracy: 0.9785  
Epoch 6/30  
888/888 - 17s - loss: 7.2999 - accuracy: 0.5213

Epoch 6/10  
 888/888 - 18s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 9/30  
 592/592 - 12s - loss: 7.2965 - accuracy: 0.5215  
 Epoch 9/10  
 592/592 - 12s - loss: 5.5391 - accuracy: 0.5972  
 Epoch 6/30  
 888/888 - 17s - loss: 0.5774 - accuracy: 0.7529  
 Epoch 9/10  
 592/592 - 11s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 9/10  
 592/592 - 12s - loss: 7.2965 - accuracy: 0.5215  
 Epoch 6/10  
 888/888 - 18s - loss: 7.2965 - accuracy: 0.5215  
 Epoch 6/30  
 888/888 - 18s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 6/10  
 888/888 - 18s - loss: 0.5391 - accuracy: 0.7641  
 Epoch 10/10  
 592/592 - 11s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 10/30  
 592/592 - 12s - loss: 7.2965 - accuracy: 0.5215  
 Epoch 10/10  
 592/592 - 12s - loss: 7.6199 - accuracy: 0.5000  
  
 2022-03-05 13:43:48.657080: I  
 tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
 Plugin optimizer for device\_type GPU is enabled.  
 2022-03-05 13:43:48.838988: I  
 tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
 Plugin optimizer for device\_type GPU is enabled.  
  
 Epoch 10/10  
 592/592 - 11s - loss: 7.2965 - accuracy: 0.5215  
  
 2022-03-05 13:43:49.133623: I  
 tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
 Plugin optimizer for device\_type GPU is enabled.  
  
 296/296 - 4s - loss: 15.4250 - accuracy: 0.0000e+00  
 296/296 - 4s - loss: 14.5784 - accuracy: 0.0430  
 296/296 - 4s - loss: 15.2492 - accuracy: 0.0000e+00  
 Epoch 7/30  
 888/888 - 17s - loss: 7.2999 - accuracy: 0.5213  
 Epoch 7/10  
 888/888 - 17s - loss: 0.3319 - accuracy: 0.9785  
  
 2022-03-05 13:43:53.311018: I  
 tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
 Plugin optimizer for device\_type GPU is enabled.

2022-03-05 13:43:53.548353: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.

Epoch 7/30  
888/888 - 17s - loss: 0.5333 - accuracy: 0.7659  
Epoch 7/10  
888/888 - 16s - loss: 0.5355 - accuracy: 0.7678  
Epoch 7/10  
888/888 - 16s - loss: 7.2965 - accuracy: 0.5215  
Epoch 7/30  
888/888 - 17s - loss: 0.3319 - accuracy: 0.9785  
Epoch 11/30  
592/592 - 10s - loss: 7.2965 - accuracy: 0.5215  
Epoch 1/30  
592/592 - 11s - loss: 0.3340 - accuracy: 0.9781  
Epoch 1/30  
592/592 - 11s - loss: 7.7111 - accuracy: 0.5000  
Epoch 8/30  
888/888 - 16s - loss: 7.2999 - accuracy: 0.5213  
Epoch 12/30  
592/592 - 11s - loss: 7.2965 - accuracy: 0.5215  
Epoch 8/10  
888/888 - 16s - loss: 0.3319 - accuracy: 0.9785  
Epoch 8/30  
888/888 - 16s - loss: 0.5183 - accuracy: 0.7677  
Epoch 8/10  
888/888 - 16s - loss: 7.2965 - accuracy: 0.5215  
Epoch 8/10  
888/888 - 16s - loss: 0.5546 - accuracy: 0.7683  
Epoch 8/30  
888/888 - 16s - loss: 0.3319 - accuracy: 0.9785  
Epoch 2/30  
592/592 - 10s - loss: 0.3319 - accuracy: 0.9785  
Epoch 2/30  
592/592 - 10s - loss: 7.7125 - accuracy: 0.5000  
Epoch 13/30  
592/592 - 10s - loss: 7.2965 - accuracy: 0.5215  
Epoch 9/10  
888/888 - 16s - loss: 0.3319 - accuracy: 0.9785  
Epoch 9/30  
888/888 - 16s - loss: 7.2999 - accuracy: 0.5213  
Epoch 3/30  
592/592 - 11s - loss: 7.7125 - accuracy: 0.5000  
Epoch 3/30  
592/592 - 11s - loss: 0.3319 - accuracy: 0.9785  
Epoch 9/30  
888/888 - 16s - loss: 0.5120 - accuracy: 0.7714

Epoch 9/10  
888/888 - 15s - loss: 7.2965 - accuracy: 0.5215  
Epoch 9/30  
888/888 - 15s - loss: 0.3319 - accuracy: 0.9785  
Epoch 9/10  
888/888 - 16s - loss: 0.5470 - accuracy: 0.7633  
Epoch 14/30  
592/592 - 11s - loss: 7.2965 - accuracy: 0.5215  
Epoch 4/30  
592/592 - 10s - loss: 7.7125 - accuracy: 0.5000  
Epoch 4/30  
592/592 - 11s - loss: 0.3319 - accuracy: 0.9785  
Epoch 10/10  
888/888 - 16s - loss: 0.3319 - accuracy: 0.9785  
2022-03-05 13:44:40.507897: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
Epoch 15/30  
592/592 - 11s - loss: 7.2965 - accuracy: 0.5215  
Epoch 10/30  
888/888 - 16s - loss: 7.2999 - accuracy: 0.5213  
Epoch 10/10  
888/888 - 16s - loss: 0.6772 - accuracy: 0.7251  
Epoch 10/30  
888/888 - 16s - loss: 0.5027 - accuracy: 0.7714  
Epoch 10/10  
888/888 - 16s - loss: 7.2965 - accuracy: 0.5215  
Epoch 10/30  
888/888 - 16s - loss: 0.3319 - accuracy: 0.9785  
2022-03-05 13:44:41.562635: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 13:44:41.754015: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
Epoch 5/30  
592/592 - 10s - loss: 7.7125 - accuracy: 0.5000  
Epoch 5/30  
592/592 - 10s - loss: 0.3319 - accuracy: 0.9785  
444/444 - 5s - loss: 15.4250 - accuracy: 0.0000e+00  
444/444 - 5s - loss: 0.6338 - accuracy: 0.8382  
444/444 - 5s - loss: 15.2492 - accuracy: 0.0000e+00  
Epoch 16/30  
592/592 - 8s - loss: 7.2965 - accuracy: 0.5215  
Epoch 6/30  
592/592 - 7s - loss: 7.7125 - accuracy: 0.5000

Epoch 11/30  
888/888 - 12s - loss: 7.2999 - accuracy: 0.5213  
Epoch 6/30  
592/592 - 8s - loss: 0.3319 - accuracy: 0.9785  
Epoch 11/30  
888/888 - 12s - loss: 0.5037 - accuracy: 0.7758  
Epoch 11/30  
888/888 - 12s - loss: 0.3319 - accuracy: 0.9785  
Epoch 17/30  
592/592 - 7s - loss: 7.2965 - accuracy: 0.5215  
Epoch 7/30  
592/592 - 7s - loss: 7.7125 - accuracy: 0.5000  
Epoch 7/30  
592/592 - 7s - loss: 0.3319 - accuracy: 0.9785  
Epoch 12/30  
888/888 - 10s - loss: 7.2999 - accuracy: 0.5213  
Epoch 18/30  
592/592 - 7s - loss: 7.2965 - accuracy: 0.5215  
Epoch 12/30  
888/888 - 11s - loss: 0.5052 - accuracy: 0.7716  
Epoch 12/30  
888/888 - 11s - loss: 0.3319 - accuracy: 0.9785  
Epoch 8/30  
592/592 - 7s - loss: 7.7125 - accuracy: 0.5000  
Epoch 8/30  
592/592 - 7s - loss: 0.3319 - accuracy: 0.9785  
Epoch 19/30  
592/592 - 7s - loss: 7.2965 - accuracy: 0.5215  
Epoch 13/30  
888/888 - 11s - loss: 7.2999 - accuracy: 0.5213  
Epoch 9/30  
592/592 - 7s - loss: 7.7125 - accuracy: 0.5000  
Epoch 13/30  
888/888 - 11s - loss: 0.5129 - accuracy: 0.7778  
Epoch 9/30  
592/592 - 7s - loss: 0.3319 - accuracy: 0.9785  
Epoch 13/30  
888/888 - 11s - loss: 0.3319 - accuracy: 0.9785  
Epoch 20/30  
592/592 - 7s - loss: 7.2965 - accuracy: 0.5215  
Epoch 10/30  
592/592 - 7s - loss: 7.7125 - accuracy: 0.5000  
Epoch 10/30  
592/592 - 7s - loss: 0.3319 - accuracy: 0.9785  
Epoch 14/30  
888/888 - 11s - loss: 7.2999 - accuracy: 0.5213  
Epoch 21/30  
592/592 - 7s - loss: 7.2965 - accuracy: 0.5215

Epoch 14/30  
888/888 - 11s - loss: 0.4938 - accuracy: 0.7801  
Epoch 14/30  
888/888 - 11s - loss: 0.3319 - accuracy: 0.9785  
Epoch 11/30  
592/592 - 7s - loss: 7.7125 - accuracy: 0.5000  
Epoch 11/30  
592/592 - 7s - loss: 0.3319 - accuracy: 0.9785  
Epoch 22/30  
592/592 - 7s - loss: 7.2965 - accuracy: 0.5215  
Epoch 15/30  
888/888 - 11s - loss: 7.2999 - accuracy: 0.5213  
Epoch 12/30  
592/592 - 7s - loss: 7.7125 - accuracy: 0.5000  
Epoch 15/30  
888/888 - 11s - loss: 0.5072 - accuracy: 0.7769  
Epoch 15/30  
888/888 - 11s - loss: 0.3319 - accuracy: 0.9785  
Epoch 12/30  
592/592 - 7s - loss: 0.3319 - accuracy: 0.9785  
Epoch 23/30  
592/592 - 7s - loss: 7.2965 - accuracy: 0.5215  
Epoch 13/30  
592/592 - 7s - loss: 7.7125 - accuracy: 0.5000  
Epoch 13/30  
592/592 - 7s - loss: 0.3319 - accuracy: 0.9785  
Epoch 16/30  
888/888 - 11s - loss: 7.2999 - accuracy: 0.5213  
Epoch 24/30  
592/592 - 7s - loss: 7.2965 - accuracy: 0.5215  
Epoch 16/30  
888/888 - 11s - loss: 0.4904 - accuracy: 0.7805  
Epoch 16/30  
888/888 - 11s - loss: 0.3319 - accuracy: 0.9785  
Epoch 14/30  
592/592 - 7s - loss: 7.7125 - accuracy: 0.5000  
Epoch 14/30  
592/592 - 7s - loss: 0.3319 - accuracy: 0.9785  
Epoch 25/30  
592/592 - 7s - loss: 7.2965 - accuracy: 0.5215  
Epoch 17/30  
888/888 - 11s - loss: 7.2999 - accuracy: 0.5213  
Epoch 15/30  
592/592 - 7s - loss: 7.7125 - accuracy: 0.5000  
Epoch 17/30  
888/888 - 11s - loss: 0.5098 - accuracy: 0.7840  
Epoch 17/30  
888/888 - 11s - loss: 0.3319 - accuracy: 0.9785



Epoch 15/30  
592/592 - 7s - loss: 0.3319 - accuracy: 0.9785  
Epoch 26/30  
592/592 - 7s - loss: 7.2965 - accuracy: 0.5215  
Epoch 16/30  
592/592 - 7s - loss: 7.7125 - accuracy: 0.5000  
Epoch 16/30  
592/592 - 7s - loss: 0.3319 - accuracy: 0.9785  
Epoch 18/30  
888/888 - 11s - loss: 7.2999 - accuracy: 0.5213  
Epoch 27/30  
592/592 - 7s - loss: 7.2965 - accuracy: 0.5215  
Epoch 18/30  
888/888 - 10s - loss: 0.3319 - accuracy: 0.9785  
Epoch 18/30  
888/888 - 11s - loss: 0.5782 - accuracy: 0.7529  
Epoch 17/30  
592/592 - 7s - loss: 7.7125 - accuracy: 0.5000  
Epoch 17/30  
592/592 - 7s - loss: 0.3319 - accuracy: 0.9785  
Epoch 28/30  
592/592 - 7s - loss: 7.2965 - accuracy: 0.5215  
Epoch 19/30  
888/888 - 10s - loss: 7.2999 - accuracy: 0.5213  
Epoch 18/30  
592/592 - 7s - loss: 7.7125 - accuracy: 0.5000  
Epoch 19/30  
888/888 - 11s - loss: 0.4961 - accuracy: 0.7801  
Epoch 19/30  
888/888 - 11s - loss: 0.3319 - accuracy: 0.9785  
Epoch 18/30  
592/592 - 7s - loss: 0.3319 - accuracy: 0.9785  
Epoch 29/30  
592/592 - 7s - loss: 7.2965 - accuracy: 0.5215  
Epoch 19/30  
592/592 - 7s - loss: 7.7125 - accuracy: 0.5000  
Epoch 19/30  
592/592 - 7s - loss: 0.3319 - accuracy: 0.9785  
Epoch 20/30  
888/888 - 11s - loss: 7.2999 - accuracy: 0.5213  
Epoch 30/30  
592/592 - 7s - loss: 7.2965 - accuracy: 0.5215  
Epoch 20/30  
888/888 - 10s - loss: 0.3319 - accuracy: 0.9785  
Epoch 20/30  
888/888 - 11s - loss: 0.4981 - accuracy: 0.7840  
2022-03-05 13:46:29.403400: I

tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.

296/296 - 3s - loss: 15.2464 - accuracy: 0.0000e+00

Epoch 20/30

592/592 - 7s - loss: 7.7125 - accuracy: 0.5000

Epoch 20/30

592/592 - 7s - loss: 0.3319 - accuracy: 0.9785

Epoch 21/30

888/888 - 9s - loss: 7.2999 - accuracy: 0.5213

Epoch 21/30

888/888 - 9s - loss: 0.4859 - accuracy: 0.7850

Epoch 21/30

888/888 - 9s - loss: 0.3319 - accuracy: 0.9785

Epoch 21/30

592/592 - 6s - loss: 7.7125 - accuracy: 0.5000

Epoch 21/30

592/592 - 6s - loss: 0.3319 - accuracy: 0.9785

Epoch 22/30

592/592 - 6s - loss: 7.7125 - accuracy: 0.5000

Epoch 22/30

592/592 - 6s - loss: 0.3319 - accuracy: 0.9785

Epoch 22/30

888/888 - 9s - loss: 7.2999 - accuracy: 0.5213

Epoch 22/30

888/888 - 9s - loss: 0.4868 - accuracy: 0.7812

Epoch 22/30

888/888 - 9s - loss: 0.3319 - accuracy: 0.9785

Epoch 23/30

592/592 - 6s - loss: 7.7125 - accuracy: 0.5000

Epoch 23/30

592/592 - 6s - loss: 0.3319 - accuracy: 0.9785

Epoch 23/30

888/888 - 9s - loss: 7.2999 - accuracy: 0.5213

Epoch 23/30

888/888 - 9s - loss: 0.5174 - accuracy: 0.7730

Epoch 23/30

888/888 - 9s - loss: 0.3319 - accuracy: 0.9785

Epoch 24/30

592/592 - 6s - loss: 7.7125 - accuracy: 0.5000

Epoch 24/30

592/592 - 6s - loss: 0.3319 - accuracy: 0.9785

Epoch 25/30

592/592 - 6s - loss: 7.7125 - accuracy: 0.5000

Epoch 25/30

592/592 - 6s - loss: 0.3319 - accuracy: 0.9785

Epoch 24/30

888/888 - 9s - loss: 7.2999 - accuracy: 0.5213

```

Epoch 24/30
888/888 - 9s - loss: 0.4886 - accuracy: 0.7857
Epoch 24/30
888/888 - 9s - loss: 0.3319 - accuracy: 0.9785
Epoch 26/30
592/592 - 6s - loss: 7.7125 - accuracy: 0.5000
Epoch 26/30
592/592 - 6s - loss: 0.3319 - accuracy: 0.9785
Epoch 25/30
888/888 - 9s - loss: 7.2999 - accuracy: 0.5213
Epoch 25/30
888/888 - 9s - loss: 0.5204 - accuracy: 0.7704
Epoch 25/30
888/888 - 9s - loss: 0.3319 - accuracy: 0.9785
Epoch 27/30
592/592 - 6s - loss: 7.7125 - accuracy: 0.5000
Epoch 27/30
592/592 - 6s - loss: 0.3319 - accuracy: 0.9785
Epoch 28/30
592/592 - 6s - loss: 7.7125 - accuracy: 0.5000
Epoch 28/30
592/592 - 6s - loss: 0.3319 - accuracy: 0.9785
Epoch 26/30
888/888 - 9s - loss: 7.2999 - accuracy: 0.5213
Epoch 26/30
888/888 - 9s - loss: 0.5836 - accuracy: 0.7731
Epoch 26/30
888/888 - 9s - loss: 0.3319 - accuracy: 0.9785
Epoch 29/30
592/592 - 6s - loss: 7.7125 - accuracy: 0.5000
Epoch 29/30
592/592 - 6s - loss: 0.3319 - accuracy: 0.9785
Epoch 27/30
888/888 - 9s - loss: 7.2999 - accuracy: 0.5213
Epoch 27/30
888/888 - 9s - loss: 0.4939 - accuracy: 0.7779
Epoch 27/30
888/888 - 9s - loss: 0.3319 - accuracy: 0.9785
Epoch 30/30
592/592 - 6s - loss: 7.7125 - accuracy: 0.5000
Epoch 30/30
592/592 - 6s - loss: 0.3319 - accuracy: 0.9785

2022-03-05 13:47:33.511175: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:47:33.630680: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]

```

```

Plugin optimizer for device_type GPU is enabled.
296/296 - 2s - loss: 0.6638 - accuracy: 0.9570
296/296 - 2s - loss: 15.4250 - accuracy: 0.0000e+00
Epoch 28/30
888/888 - 7s - loss: 7.2999 - accuracy: 0.5213
Epoch 28/30
888/888 - 7s - loss: 0.4910 - accuracy: 0.7772
Epoch 28/30
888/888 - 7s - loss: 0.3319 - accuracy: 0.9785
Epoch 29/30
888/888 - 6s - loss: 7.2999 - accuracy: 0.5213
Epoch 29/30
888/888 - 6s - loss: 0.4842 - accuracy: 0.7885
Epoch 29/30
888/888 - 6s - loss: 0.3319 - accuracy: 0.9785
Epoch 30/30
888/888 - 6s - loss: 7.2999 - accuracy: 0.5213

2022-03-05 13:47:50.197887: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 30/30
888/888 - 6s - loss: 0.4913 - accuracy: 0.7877
Epoch 30/30
888/888 - 6s - loss: 0.3319 - accuracy: 0.9785

2022-03-05 13:47:50.789324: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:47:50.959357: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

444/444 - 2s - loss: 15.2492 - accuracy: 0.0000e+00
444/444 - 2s - loss: 0.5457 - accuracy: 0.7911
444/444 - 2s - loss: 15.3846 - accuracy: 0.0000e+00
Epoch 1/30

2022-03-05 13:47:52.790600: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

888/888 - 5s - loss: 9.9474 - accuracy: 0.3477
Epoch 2/30
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477
Epoch 3/30
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477
Epoch 4/30
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477

```

Epoch 5/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 6/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 7/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 8/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 9/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 10/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 11/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 12/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 13/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 14/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 15/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 16/30

systemMemory: 32.00 GB  
maxCacheSize: 10.67 GB

888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 17/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 18/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 19/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 20/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 21/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 22/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 23/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 24/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 25/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477  
Epoch 26/30  
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477

```
Epoch 27/30
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477
Epoch 28/30
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477
Epoch 29/30
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477
Epoch 30/30
```

```
systemMemory: 32.00 GB
maxCacheSize: 10.67 GB
```

```
systemMemory: 32.00 GB
maxCacheSize: 10.67 GB
```

```
systemMemory: 32.00 GB
maxCacheSize: 10.67 GB
```

```
888/888 - 4s - loss: 9.9474 - accuracy: 0.3477
```

```
[28]: # summarize results
print("Best: %f using %s" % (grid_result.best_score_, grid_result.best_params_))
means = grid_result.cv_results_['mean_test_score']
stds = grid_result.cv_results_['std_test_score']
params = grid_result.cv_results_['params']
for mean, stdev, param in zip(means, stds, params):
    print("%f (%f) with: %r" % (mean, stdev, param))
```

```
Best: 0.318988 using {'batch_size': 15, 'epochs': 30}
0.279405 (0.395139) with: {'batch_size': 10, 'epochs': 10}
0.263707 (0.372939) with: {'batch_size': 10, 'epochs': 30}
0.014346 (0.020288) with: {'batch_size': 15, 'epochs': 10}
0.318988 (0.451117) with: {'batch_size': 15, 'epochs': 30}
```

## Tune the Training Optimization Algorithm

```
[29]: # define the grid search parameters
optimizer = ['SGD', 'RMSprop', 'Adam']
param_grid = dict(optimizer=optimizer)
grid = GridSearchCV(estimator=model, param_grid=param_grid, n_jobs=-1, cv=3)
grid_result = grid.fit(X_train, y_train)
```

```
2022-03-05 13:49:48.368190: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:49:48.404912: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
```

```

Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:49:48.437532: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:49:48.798108: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:49:48.869954: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:49:48.891055: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 1/20
278/278 - 4s - loss: 7.7125 - accuracy: 0.5000
Epoch 1/20
278/278 - 4s - loss: 0.4336 - accuracy: 0.9717
Epoch 1/20
278/278 - 4s - loss: 7.3219 - accuracy: 0.5186
Epoch 1/20
278/278 - 5s - loss: 5.8319 - accuracy: 0.6137
Epoch 1/20
278/278 - 5s - loss: 6.1374 - accuracy: 0.5911
Epoch 1/20
278/278 - 5s - loss: 5.1195 - accuracy: 0.6365
Epoch 2/20
278/278 - 3s - loss: 7.7125 - accuracy: 0.5000
Epoch 2/20
278/278 - 3s - loss: 0.3319 - accuracy: 0.9785
Epoch 2/20
278/278 - 3s - loss: 7.2965 - accuracy: 0.5215
Init Plugin
Init Graph Optimizer
Init Kernel
Init Plugin
Init Graph Optimizer
Init Kernel
Init Plugin
Init Graph Optimizer
Init Kernel
Metal device set to: Apple M1 Pro
Metal device set to: Apple M1 Pro
Metal device set to: Apple M1 Pro

2022-03-05 13:49:57.118865: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.

```

```

2022-03-05 13:49:57.119032: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0
MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:
<undefined>)
2022-03-05 13:49:57.119080: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.
2022-03-05 13:49:57.119210: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0
MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:
<undefined>)
2022-03-05 13:49:57.119207: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.
2022-03-05 13:49:57.119353: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0
MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:
<undefined>)

Epoch 2/20
278/278 - 4s - loss: 0.3287 - accuracy: 0.9786
Epoch 2/20
278/278 - 4s - loss: 4.8375 - accuracy: 0.6630
Epoch 2/20
278/278 - 4s - loss: 2.1868 - accuracy: 0.7068
Epoch 3/20
278/278 - 3s - loss: 7.7125 - accuracy: 0.5000
Epoch 3/20
278/278 - 3s - loss: 0.3319 - accuracy: 0.9785

2022-03-05 13:49:58.338903: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:176] None of the MLIR
Optimization Passes are enabled (registered 2)
2022-03-05 13:49:58.339085: W
tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU
frequency: 0 Hz
2022-03-05 13:49:58.384588: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:176] None of the MLIR
Optimization Passes are enabled (registered 2)
2022-03-05 13:49:58.384775: W
tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU
frequency: 0 Hz
2022-03-05 13:49:58.385354: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:176] None of the MLIR

```



Optimization Passes are enabled (registered 2)  
2022-03-05 13:49:58.385480: W  
tensorflow/core/platform/profile\_utils/cpu\_utils.cc:128] Failed to get CPU  
frequency: 0 Hz

Epoch 3/20  
278/278 - 4s - loss: 7.2965 - accuracy: 0.5215  
Epoch 4/20  
278/278 - 3s - loss: 0.3319 - accuracy: 0.9785  
Epoch 4/20  
278/278 - 3s - loss: 7.7125 - accuracy: 0.5000  
Epoch 3/20  
278/278 - 4s - loss: 0.3284 - accuracy: 0.9787  
Epoch 3/20  
278/278 - 4s - loss: 3.9070 - accuracy: 0.7182  
Epoch 3/20  
278/278 - 4s - loss: 0.9832 - accuracy: 0.7296  
Epoch 4/20  
278/278 - 4s - loss: 7.2965 - accuracy: 0.5215  
Epoch 5/20  
278/278 - 3s - loss: 7.7125 - accuracy: 0.5000  
Epoch 5/20  
278/278 - 3s - loss: 0.3319 - accuracy: 0.9785  
Epoch 4/20  
278/278 - 4s - loss: 0.3284 - accuracy: 0.9787  
Epoch 5/20  
278/278 - 4s - loss: 7.2965 - accuracy: 0.5215  
Epoch 4/20  
278/278 - 4s - loss: 2.9907 - accuracy: 0.7313  
Epoch 4/20  
278/278 - 4s - loss: 0.6805 - accuracy: 0.7614  
Epoch 6/20  
278/278 - 3s - loss: 7.7125 - accuracy: 0.5000  
Epoch 6/20  
278/278 - 3s - loss: 0.3319 - accuracy: 0.9785  
Epoch 6/20  
278/278 - 4s - loss: 7.2965 - accuracy: 0.5215

2022-03-05 13:50:09.606355: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 13:50:09.832679: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 13:50:09.847883: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.

Epoch 5/20

278/278 - 4s - loss: 0.3284 - accuracy: 0.9787  
Epoch 5/20  
278/278 - 5s - loss: 2.0216 - accuracy: 0.7444  
Epoch 5/20  
278/278 - 5s - loss: 0.6130 - accuracy: 0.7658  
Epoch 7/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 7/20  
278/278 - 4s - loss: 7.7125 - accuracy: 0.5000  
Epoch 7/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 1/20  
278/278 - 17s - loss: 0.3339 - accuracy: 0.9783  
Epoch 1/20  
278/278 - 17s - loss: 1.1845 - accuracy: 0.7160  
Epoch 1/20  
278/278 - 17s - loss: 7.1375 - accuracy: 0.5224  
Epoch 6/20  
278/278 - 6s - loss: 0.3284 - accuracy: 0.9787  
Epoch 6/20  
278/278 - 6s - loss: 1.5545 - accuracy: 0.7281  
Epoch 8/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 8/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 6/20  
278/278 - 6s - loss: 0.6190 - accuracy: 0.7713  
Epoch 8/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 2/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 2/20  
278/278 - 5s - loss: 0.6298 - accuracy: 0.7506  
Epoch 2/20  
278/278 - 5s - loss: 6.6804 - accuracy: 0.5393  
Epoch 9/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 9/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 7/20  
278/278 - 6s - loss: 0.3284 - accuracy: 0.9787  
Epoch 7/20  
278/278 - 6s - loss: 1.5618 - accuracy: 0.7261  
Epoch 7/20  
278/278 - 6s - loss: 0.5669 - accuracy: 0.7746  
Epoch 9/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 3/20

278/278 - 5s - loss: 0.6115 - accuracy: 0.7568  
Epoch 3/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 3/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 10/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 10/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 8/20  
278/278 - 6s - loss: 0.3284 - accuracy: 0.9787  
Epoch 8/20  
278/278 - 6s - loss: 1.3844 - accuracy: 0.7403  
Epoch 8/20  
278/278 - 6s - loss: 0.5922 - accuracy: 0.7749  
Epoch 10/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 4/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 4/20  
278/278 - 5s - loss: 0.5740 - accuracy: 0.7637  
Epoch 4/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 11/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 11/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 9/20  
278/278 - 6s - loss: 0.3284 - accuracy: 0.9787  
Epoch 11/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 5/20  
278/278 - 5s - loss: 0.6112 - accuracy: 0.7388  
Epoch 9/20  
278/278 - 6s - loss: 0.5802 - accuracy: 0.7794  
Epoch 9/20  
278/278 - 6s - loss: 1.3297 - accuracy: 0.7343  
Epoch 5/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 5/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 12/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 12/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 12/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 6/20

278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 6/20  
278/278 - 5s - loss: 0.5620 - accuracy: 0.7290  
Epoch 6/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 10/20  
278/278 - 6s - loss: 0.3284 - accuracy: 0.9787  
Epoch 10/20  
278/278 - 6s - loss: 1.2491 - accuracy: 0.7116  
Epoch 10/20  
278/278 - 6s - loss: 0.6614 - accuracy: 0.7623  
Epoch 13/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 13/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 13/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 7/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 7/20  
278/278 - 5s - loss: 0.5445 - accuracy: 0.7501  
Epoch 7/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 14/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 14/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 11/20  
278/278 - 6s - loss: 1.1608 - accuracy: 0.7337  
Epoch 11/20  
278/278 - 6s - loss: 0.3284 - accuracy: 0.9787  
Epoch 11/20  
278/278 - 6s - loss: 0.5855 - accuracy: 0.7553  
Epoch 14/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 8/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 8/20  
278/278 - 5s - loss: 0.8789 - accuracy: 0.7156  
Epoch 8/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 15/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 15/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 12/20  
278/278 - 6s - loss: 0.3284 - accuracy: 0.9787  
Epoch 12/20

278/278 - 6s - loss: 0.9446 - accuracy: 0.7375  
Epoch 12/20  
278/278 - 6s - loss: 0.5746 - accuracy: 0.7855  
Epoch 15/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 9/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 9/20  
278/278 - 5s - loss: 0.5950 - accuracy: 0.7260  
Epoch 9/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 16/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 16/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 13/20  
278/278 - 6s - loss: 0.3284 - accuracy: 0.9787  
Epoch 13/20  
278/278 - 6s - loss: 0.8523 - accuracy: 0.7544  
Epoch 13/20  
278/278 - 6s - loss: 0.5812 - accuracy: 0.7783  
Epoch 16/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 10/20  
278/278 - 5s - loss: 0.5479 - accuracy: 0.7445  
Epoch 10/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 10/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 17/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 17/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 14/20  
278/278 - 6s - loss: 0.3284 - accuracy: 0.9787  
Epoch 17/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 14/20  
278/278 - 6s - loss: 0.6936 - accuracy: 0.7590  
Epoch 11/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 11/20  
278/278 - 5s - loss: 0.5462 - accuracy: 0.7404  
Epoch 14/20  
278/278 - 6s - loss: 0.5662 - accuracy: 0.7839  
Epoch 11/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 18/20

```

278/278 - 5s - loss: 7.7125 - accuracy: 0.5000
Epoch 18/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 18/20
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215
Epoch 12/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 12/20
278/278 - 5s - loss: 0.5124 - accuracy: 0.7666
Epoch 12/20
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215
Epoch 19/20
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000
Epoch 15/20
278/278 - 6s - loss: 0.3284 - accuracy: 0.9787
Epoch 15/20
278/278 - 6s - loss: 0.7375 - accuracy: 0.7560
Epoch 19/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 15/20
278/278 - 6s - loss: 0.5914 - accuracy: 0.7899
Epoch 19/20
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215
Epoch 13/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 13/20
278/278 - 5s - loss: 0.6058 - accuracy: 0.7029
Epoch 13/20
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215
Epoch 20/20
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000
Epoch 20/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785

2022-03-05 13:51:16.894026: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:51:17.007352: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 16/20
278/278 - 6s - loss: 0.3284 - accuracy: 0.9787
Epoch 16/20
278/278 - 6s - loss: 0.6260 - accuracy: 0.7621
Epoch 16/20
278/278 - 6s - loss: 0.5307 - accuracy: 0.7855
139/139 - 2s - loss: 0.6638 - accuracy: 0.9570
139/139 - 2s - loss: 15.4249 - accuracy: 0.0000e+00

```

Epoch 20/20  
278/278 - 4s - loss: 7.2965 - accuracy: 0.5215

2022-03-05 13:51:20.079048: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.

Epoch 14/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785

Epoch 14/20  
278/278 - 4s - loss: 0.5376 - accuracy: 0.7565

Epoch 14/20  
278/278 - 4s - loss: 7.2965 - accuracy: 0.5215  
139/139 - 2s - loss: 15.2493 - accuracy: 0.0000e+00

Epoch 17/20  
278/278 - 5s - loss: 0.3284 - accuracy: 0.9787

Epoch 17/20  
278/278 - 5s - loss: 0.6544 - accuracy: 0.7699

Epoch 17/20  
278/278 - 5s - loss: 0.5708 - accuracy: 0.7790

Epoch 15/20  
278/278 - 4s - loss: 0.5341 - accuracy: 0.7677

Epoch 15/20  
278/278 - 4s - loss: 7.2965 - accuracy: 0.5215

Epoch 15/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785

Epoch 18/20  
278/278 - 4s - loss: 0.3284 - accuracy: 0.9787

Epoch 18/20  
278/278 - 4s - loss: 0.6091 - accuracy: 0.7753

Epoch 18/20  
278/278 - 4s - loss: 0.5840 - accuracy: 0.7823

Epoch 16/20  
278/278 - 4s - loss: 1.2914 - accuracy: 0.6805

Epoch 16/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785

Epoch 16/20  
278/278 - 4s - loss: 7.2965 - accuracy: 0.5215

Epoch 19/20  
278/278 - 4s - loss: 0.3284 - accuracy: 0.9787

Epoch 19/20  
278/278 - 4s - loss: 0.6213 - accuracy: 0.7723

Epoch 17/20  
278/278 - 3s - loss: 7.2965 - accuracy: 0.5215

Epoch 17/20  
278/278 - 4s - loss: 0.7034 - accuracy: 0.7101

Epoch 19/20  
278/278 - 4s - loss: 0.6072 - accuracy: 0.7848

Epoch 17/20

```

278/278 - 4s - loss: 0.3319 - accuracy: 0.9785
Epoch 20/20
278/278 - 4s - loss: 0.3284 - accuracy: 0.9787
Epoch 18/20
278/278 - 3s - loss: 7.2965 - accuracy: 0.5215
Epoch 18/20
278/278 - 4s - loss: 0.6385 - accuracy: 0.7218

2022-03-05 13:51:34.753323: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 18/20
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785
Epoch 20/20
278/278 - 4s - loss: 0.8098 - accuracy: 0.7775

2022-03-05 13:51:35.102190: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 20/20
278/278 - 4s - loss: 0.5919 - accuracy: 0.7848

2022-03-05 13:51:35.446364: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

139/139 - 1s - loss: 15.3287 - accuracy: 0.0059
139/139 - 1s - loss: 0.4121 - accuracy: 0.8975
139/139 - 1s - loss: 0.6762 - accuracy: 0.7972
Epoch 19/20
278/278 - 2s - loss: 7.2965 - accuracy: 0.5215
Epoch 19/20
278/278 - 2s - loss: 0.3319 - accuracy: 0.9785
Epoch 19/20
278/278 - 2s - loss: 0.5787 - accuracy: 0.7358
Epoch 20/20
278/278 - 2s - loss: 7.2965 - accuracy: 0.5215
Epoch 20/20
278/278 - 2s - loss: 0.3319 - accuracy: 0.9785
Epoch 20/20
278/278 - 2s - loss: 0.5422 - accuracy: 0.7651

2022-03-05 13:51:38.994070: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:51:39.011790: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:51:39.013485: I

```



tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.

139/139 - 1s - loss: 15.2493 - accuracy: 0.0000e+00

139/139 - 1s - loss: 15.4192 - accuracy: 0.0000e+00

139/139 - 1s - loss: 0.5586 - accuracy: 0.8267

Epoch 1/20

2022-03-05 13:51:40.187415: I

tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]

Plugin optimizer for device\_type GPU is enabled.

417/417 - 3s - loss: 9.9474 - accuracy: 0.3477

Epoch 2/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 3/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 4/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 5/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 6/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 7/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 8/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 9/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 10/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 11/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 12/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 13/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 14/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 15/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 16/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 17/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 18/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 19/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

Epoch 20/20  
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

```
[30]: # summarize results
print("Best: %f using %s" % (grid_result.best_score_, grid_result.best_params_))
means = grid_result.cv_results_['mean_test_score']
stds = grid_result.cv_results_['std_test_score']
params = grid_result.cv_results_['params']
for mean, stdev, param in zip(means, stds, params):
    print("%f (%f) with: %r" % (mean, stdev, param))
```

Best: 0.566847 using {'optimizer': 'RMSprop'}  
0.318988 (0.451117) with: {'optimizer': 'SGD'}  
0.566847 (0.398785) with: {'optimizer': 'RMSprop'}  
0.275575 (0.389721) with: {'optimizer': 'Adam'}

### Tune Learning Rate and Momentum

```
[31]: # define the grid search parameters
learn_rate = [0.01, 0.1, 0.2]
momentum = [0.0, 0.1, 0.2]
param_grid = dict(learn_rate=learn_rate, momentum=momentum)
grid = GridSearchCV(estimator=model, param_grid=param_grid, n_jobs=-1, cv=3)
grid_result = grid.fit(X_train, y_train)
```

2022-03-05 13:52:28.492803: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 13:52:28.523695: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 13:52:28.527205: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 13:52:28.534188: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 13:52:28.547417: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 13:52:28.563782: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 13:52:28.569964: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 13:52:28.592419: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]

```

Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:52:28.624773: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Init Plugin
Init Graph Optimizer
Init Kernel
Metal device set to: Apple M1 Pro

2022-03-05 13:52:30.878074: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305]
Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel
may not have been built with NUMA support.
2022-03-05 13:52:30.878217: I
tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271]
Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0
MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id:
<undefined>)
2022-03-05 13:52:31.601958: I
tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:176] None of the MLIR
Optimization Passes are enabled (registered 2)
2022-03-05 13:52:31.602148: W
tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU
frequency: 0 Hz

Epoch 1/20
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785
Epoch 1/20
278/278 - 5s - loss: 0.3365 - accuracy: 0.9777
Epoch 1/20
278/278 - 5s - loss: 7.3844 - accuracy: 0.4967
Epoch 1/20
278/278 - 5s - loss: 4.0417 - accuracy: 0.7286
Epoch 1/20
278/278 - 5s - loss: 2.8160 - accuracy: 0.5700
Epoch 1/20
278/278 - 6s - loss: 3.8550 - accuracy: 0.6219
Epoch 1/20
278/278 - 5s - loss: 0.5086 - accuracy: 0.9642
Epoch 1/20
278/278 - 6s - loss: 2.5531 - accuracy: 0.6062
Epoch 1/20
278/278 - 6s - loss: 1.4111 - accuracy: 0.6656
Epoch 2/20
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785
Epoch 2/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 2/20

```

```

278/278 - 5s - loss: 0.7791 - accuracy: 0.6782
Epoch 2/20
278/278 - 5s - loss: 2.3188 - accuracy: 0.6922
Epoch 2/20
278/278 - 5s - loss: 0.3337 - accuracy: 0.9784
Epoch 2/20
278/278 - 5s - loss: 5.8156 - accuracy: 0.5231
Epoch 2/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 2/20
278/278 - 5s - loss: 0.5731 - accuracy: 0.7412
Epoch 2/20
278/278 - 5s - loss: 0.5710 - accuracy: 0.7391
Epoch 3/20
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785
Epoch 3/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 3/20
278/278 - 5s - loss: 1.3780 - accuracy: 0.7117
Epoch 3/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 3/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 3/20
278/278 - 5s - loss: 0.5917 - accuracy: 0.7464
Epoch 3/20
278/278 - 5s - loss: 0.5283 - accuracy: 0.7596
Epoch 3/20
278/278 - 5s - loss: 6.1587 - accuracy: 0.5857
Epoch 3/20
278/278 - 5s - loss: 0.5390 - accuracy: 0.7707
Epoch 4/20
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785

2022-03-05 13:52:47.648762: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 4/20
278/278 - 5s - loss: 0.9901 - accuracy: 0.7099
Epoch 4/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 4/20
278/278 - 5s - loss: 0.5518 - accuracy: 0.7548
Epoch 4/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 4/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 4/20

```

278/278 - 5s - loss: 5.8245 - accuracy: 0.6041  
Epoch 4/20  
278/278 - 5s - loss: 0.5163 - accuracy: 0.7619  
Epoch 4/20  
278/278 - 5s - loss: 0.5311 - accuracy: 0.7589  
Epoch 5/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 1/20  
278/278 - 21s - loss: 3.8001 - accuracy: 0.5924  
Epoch 5/20  
278/278 - 5s - loss: 0.6976 - accuracy: 0.7370  
Epoch 5/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 5/20  
278/278 - 6s - loss: 0.6584 - accuracy: 0.7427  
Epoch 5/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 5/20  
278/278 - 5s - loss: 0.4950 - accuracy: 0.7653  
Epoch 5/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 5/20  
278/278 - 6s - loss: 4.8855 - accuracy: 0.6589  
Epoch 5/20  
278/278 - 6s - loss: 0.5384 - accuracy: 0.7617  
Epoch 2/20  
278/278 - 5s - loss: 0.8228 - accuracy: 0.7331  
Epoch 6/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 6/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 6/20  
278/278 - 6s - loss: 0.6064 - accuracy: 0.7559  
Epoch 6/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 6/20  
278/278 - 5s - loss: 0.6592 - accuracy: 0.7411  
Epoch 6/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 6/20  
278/278 - 5s - loss: 4.1480 - accuracy: 0.6984  
Epoch 6/20  
278/278 - 6s - loss: 0.5479 - accuracy: 0.7569  
Epoch 6/20  
278/278 - 6s - loss: 0.5157 - accuracy: 0.7722  
Epoch 3/20  
278/278 - 6s - loss: 0.5964 - accuracy: 0.7526  
Epoch 7/20

278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 7/20  
278/278 - 5s - loss: 0.5821 - accuracy: 0.7586  
Epoch 7/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 7/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 7/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 7/20  
278/278 - 5s - loss: 0.5723 - accuracy: 0.7495  
Epoch 7/20  
278/278 - 5s - loss: 6.3622 - accuracy: 0.5714  
Epoch 7/20  
278/278 - 5s - loss: 0.5191 - accuracy: 0.7705  
Epoch 7/20  
278/278 - 6s - loss: 0.5107 - accuracy: 0.7735  
Epoch 4/20  
278/278 - 5s - loss: 0.5485 - accuracy: 0.7544  
Epoch 8/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 8/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 8/20  
278/278 - 5s - loss: 0.5330 - accuracy: 0.7499  
Epoch 8/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 8/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 8/20  
278/278 - 6s - loss: 0.6457 - accuracy: 0.7262  
Epoch 8/20  
278/278 - 5s - loss: 0.5037 - accuracy: 0.7747  
Epoch 8/20  
278/278 - 5s - loss: 0.5037 - accuracy: 0.7764  
Epoch 8/20  
278/278 - 6s - loss: 7.5804 - accuracy: 0.5001  
Epoch 5/20  
278/278 - 5s - loss: 0.5320 - accuracy: 0.7621  
Epoch 9/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 9/20  
278/278 - 5s - loss: 0.5271 - accuracy: 0.7557  
Epoch 9/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 9/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 9/20

278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 9/20  
278/278 - 5s - loss: 0.5385 - accuracy: 0.7581  
Epoch 9/20  
278/278 - 5s - loss: 0.5304 - accuracy: 0.7617  
Epoch 9/20  
278/278 - 6s - loss: 0.5153 - accuracy: 0.7617  
Epoch 9/20  
278/278 - 6s - loss: 6.0382 - accuracy: 0.5864  
Epoch 6/20  
278/278 - 5s - loss: 0.6940 - accuracy: 0.6657  
Epoch 10/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 10/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 10/20  
278/278 - 6s - loss: 0.5128 - accuracy: 0.7635  
Epoch 10/20  
278/278 - 5s - loss: 0.5928 - accuracy: 0.7391  
Epoch 10/20  
278/278 - 5s - loss: 0.4941 - accuracy: 0.7769  
Epoch 10/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 10/20  
278/278 - 6s - loss: 0.5054 - accuracy: 0.7752  
Epoch 10/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 10/20  
278/278 - 5s - loss: 4.3335 - accuracy: 0.6931  
Epoch 7/20  
278/278 - 5s - loss: 0.6345 - accuracy: 0.6545  
Epoch 11/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 11/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 11/20  
278/278 - 5s - loss: 0.5080 - accuracy: 0.7748  
Epoch 11/20  
278/278 - 5s - loss: 0.4934 - accuracy: 0.7776  
Epoch 11/20  
278/278 - 6s - loss: 0.5107 - accuracy: 0.7701  
Epoch 11/20  
278/278 - 5s - loss: 0.5036 - accuracy: 0.7750  
Epoch 11/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 11/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 11/20

278/278 - 5s - loss: 4.4559 - accuracy: 0.6781  
 Epoch 8/20  
 278/278 - 5s - loss: 0.5991 - accuracy: 0.6752  
 Epoch 12/20  
 278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 12/20  
 278/278 - 5s - loss: 0.5125 - accuracy: 0.7719  
 Epoch 12/20  
 278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
 Epoch 12/20  
 278/278 - 5s - loss: 0.4864 - accuracy: 0.7788  
 Epoch 12/20  
 278/278 - 5s - loss: 0.8459 - accuracy: 0.7288  
 Epoch 12/20  
 278/278 - 5s - loss: 0.5085 - accuracy: 0.7668  
 Epoch 12/20  
 278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 12/20  
 278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 12/20  
 278/278 - 6s - loss: 3.6499 - accuracy: 0.7393  
 Epoch 9/20  
 278/278 - 5s - loss: 0.5737 - accuracy: 0.7094  
 Epoch 13/20  
 278/278 - 5s - loss: 0.5273 - accuracy: 0.7607  
 Epoch 13/20  
 278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 13/20  
 278/278 - 5s - loss: 0.5039 - accuracy: 0.7697  
 Epoch 13/20  
 278/278 - 5s - loss: 0.9193 - accuracy: 0.6665  
 Epoch 13/20  
 278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
 Epoch 13/20  
 278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 13/20  
 278/278 - 6s - loss: 2.1748 - accuracy: 0.6760  
 Epoch 13/20  
 278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 13/20  
 278/278 - 6s - loss: 3.7447 - accuracy: 0.7322  
 Epoch 10/20  
 278/278 - 5s - loss: 0.5493 - accuracy: 0.7336  
 Epoch 14/20  
 278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 14/20  
 278/278 - 5s - loss: 0.5330 - accuracy: 0.7615  
 Epoch 14/20



278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 14/20  
278/278 - 5s - loss: 0.5833 - accuracy: 0.7443  
Epoch 14/20  
278/278 - 6s - loss: 0.5071 - accuracy: 0.7710  
Epoch 14/20  
278/278 - 5s - loss: 0.6012 - accuracy: 0.7393  
Epoch 14/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 14/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 14/20  
278/278 - 6s - loss: 4.3946 - accuracy: 0.6851  
Epoch 11/20  
278/278 - 6s - loss: 0.5351 - accuracy: 0.7529  
Epoch 15/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 15/20  
278/278 - 5s - loss: 0.5486 - accuracy: 0.7605  
Epoch 15/20  
278/278 - 6s - loss: 0.5311 - accuracy: 0.7639  
Epoch 15/20  
278/278 - 5s - loss: 0.5057 - accuracy: 0.7686  
Epoch 15/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 15/20  
278/278 - 5s - loss: 0.6537 - accuracy: 0.7503  
Epoch 15/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 15/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 15/20  
278/278 - 6s - loss: 3.9241 - accuracy: 0.7154  
Epoch 12/20  
278/278 - 5s - loss: 0.5432 - accuracy: 0.7600  
Epoch 16/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 16/20  
278/278 - 5s - loss: 0.5290 - accuracy: 0.7684  
Epoch 16/20  
278/278 - 5s - loss: 0.5432 - accuracy: 0.7463  
Epoch 16/20  
278/278 - 6s - loss: 0.5287 - accuracy: 0.7526  
Epoch 16/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 16/20  
278/278 - 6s - loss: 0.6022 - accuracy: 0.7298  
Epoch 16/20

278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 16/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 16/20  
278/278 - 5s - loss: 3.6897 - accuracy: 0.7326  
Epoch 13/20  
278/278 - 5s - loss: 0.5316 - accuracy: 0.7654  
Epoch 17/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 17/20  
278/278 - 5s - loss: 0.5025 - accuracy: 0.7735  
Epoch 17/20  
278/278 - 5s - loss: 0.8138 - accuracy: 0.7401  
Epoch 17/20  
278/278 - 5s - loss: 0.5295 - accuracy: 0.7678  
Epoch 17/20  
278/278 - 6s - loss: 0.5019 - accuracy: 0.7652  
Epoch 17/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 17/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 17/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 17/20  
278/278 - 5s - loss: 3.6395 - accuracy: 0.7339  
Epoch 14/20  
278/278 - 5s - loss: 0.5139 - accuracy: 0.7678  
Epoch 18/20  
278/278 - 6s - loss: 0.5448 - accuracy: 0.7577  
Epoch 18/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 18/20  
278/278 - 5s - loss: 0.7993 - accuracy: 0.6384  
Epoch 18/20  
278/278 - 5s - loss: 0.5181 - accuracy: 0.7743  
Epoch 18/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 18/20  
278/278 - 5s - loss: 0.4883 - accuracy: 0.7697  
Epoch 18/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 18/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 18/20  
278/278 - 6s - loss: 3.7848 - accuracy: 0.7224  
Epoch 15/20  
278/278 - 5s - loss: 0.5235 - accuracy: 0.7604  
Epoch 19/20

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278/278 - 5s - loss: 0.4856 - accuracy: 0.7767
Epoch 19/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 19/20
278/278 - 5s - loss: 0.5174 - accuracy: 0.7757
Epoch 19/20
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785
Epoch 19/20
278/278 - 6s - loss: 0.5640 - accuracy: 0.7326
Epoch 19/20
278/278 - 5s - loss: 0.4813 - accuracy: 0.7687
Epoch 19/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 19/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 19/20
278/278 - 6s - loss: 6.4787 - accuracy: 0.5662
Epoch 16/20
278/278 - 6s - loss: 0.5790 - accuracy: 0.7546
Epoch 20/20
278/278 - 6s - loss: 0.4853 - accuracy: 0.7752
Epoch 20/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785

2022-03-05 13:54:15.239182: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:54:15.345268: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 20/20
278/278 - 5s - loss: 0.5043 - accuracy: 0.7786
Epoch 20/20
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785
Epoch 20/20
278/278 - 5s - loss: 0.5306 - accuracy: 0.7740

2022-03-05 13:54:15.694315: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:54:15.703837: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:54:15.821187: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 20/20
278/278 - 5s - loss: 0.4751 - accuracy: 0.7725

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2022-03-05 13:54:16.004911: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 20/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 20/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785

2022-03-05 13:54:16.275625: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:54:16.337099: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 20/20
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000
139/139 - 2s - loss: 0.5043 - accuracy: 0.8346
139/139 - 2s - loss: 15.4015 - accuracy: 0.0011

2022-03-05 13:54:16.902686: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

139/139 - 2s - loss: 0.4832 - accuracy: 0.8574
139/139 - 2s - loss: 0.0000e+00 - accuracy: 1.0000
139/139 - 1s - loss: 0.4802 - accuracy: 0.8565
139/139 - 1s - loss: 0.5035 - accuracy: 0.7704
139/139 - 1s - loss: 15.4217 - accuracy: 0.0000e+00
139/139 - 1s - loss: 15.4215 - accuracy: 2.2533e-04
139/139 - 1s - loss: 14.5930 - accuracy: 0.0430
Epoch 17/20
278/278 - 3s - loss: 0.5155 - accuracy: 0.7720

2022-03-05 13:54:17.749894: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:54:17.773892: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:54:17.932737: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:54:17.965007: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:54:18.020202: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:54:18.114231: I

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tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:54:18.311966: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:54:18.388980: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:54:18.581984: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 18/20
278/278 - 5s - loss: 0.5769 - accuracy: 0.7537
Epoch 1/20
278/278 - 6s - loss: 1.3408 - accuracy: 0.6630
Epoch 1/20
278/278 - 6s - loss: 0.4775 - accuracy: 0.9673
Epoch 1/20
278/278 - 6s - loss: 6.0345 - accuracy: 0.5525
Epoch 1/20
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785
Epoch 1/20
278/278 - 6s - loss: 0.4174 - accuracy: 0.9687
Epoch 1/20
278/278 - 6s - loss: 5.3618 - accuracy: 0.5922
Epoch 1/20
278/278 - 6s - loss: 0.3308 - accuracy: 0.9784
Epoch 1/20
278/278 - 6s - loss: 2.5866 - accuracy: 0.5792
Epoch 1/20
278/278 - 6s - loss: 0.9666 - accuracy: 0.6996
Epoch 19/20
278/278 - 6s - loss: 0.6601 - accuracy: 0.6924
Epoch 2/20
278/278 - 5s - loss: 0.3267 - accuracy: 0.9788
Epoch 2/20
278/278 - 6s - loss: 0.5549 - accuracy: 0.7675
Epoch 2/20
278/278 - 5s - loss: 1.5906 - accuracy: 0.6478
Epoch 2/20
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785
Epoch 2/20
278/278 - 5s - loss: 4.1031 - accuracy: 0.6797
Epoch 2/20
278/278 - 6s - loss: 0.3270 - accuracy: 0.9787
Epoch 2/20
278/278 - 5s - loss: 0.5582 - accuracy: 0.7582

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Epoch 2/20  
278/278 - 6s - loss: 0.3302 - accuracy: 0.9786  
Epoch 2/20  
278/278 - 6s - loss: 1.1182 - accuracy: 0.6636  
Epoch 3/20  
278/278 - 5s - loss: 0.5574 - accuracy: 0.7477  
Epoch 20/20  
278/278 - 6s - loss: 0.6529 - accuracy: 0.7210  
Epoch 3/20  
278/278 - 5s - loss: 0.3267 - accuracy: 0.9788  
Epoch 3/20  
278/278 - 5s - loss: 0.6280 - accuracy: 0.6692

2022-03-05 13:54:34.029888: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.

Epoch 3/20  
278/278 - 5s - loss: 3.9452 - accuracy: 0.6977  
Epoch 3/20  
278/278 - 5s - loss: 0.3275 - accuracy: 0.9785  
Epoch 3/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 3/20  
278/278 - 5s - loss: 0.5174 - accuracy: 0.7623  
Epoch 3/20  
278/278 - 5s - loss: 1.9178 - accuracy: 0.6714  
Epoch 3/20  
278/278 - 6s - loss: 0.3302 - accuracy: 0.9786  
139/139 - 2s - loss: 0.7972 - accuracy: 0.7832

2022-03-05 13:54:37.138905: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.

Epoch 4/20  
278/278 - 5s - loss: 0.5226 - accuracy: 0.7697  
Epoch 4/20  
278/278 - 5s - loss: 0.6257 - accuracy: 0.6817  
Epoch 4/20  
278/278 - 5s - loss: 0.3267 - accuracy: 0.9788  
Epoch 4/20  
278/278 - 5s - loss: 3.9983 - accuracy: 0.7096  
Epoch 4/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 4/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 4/20  
278/278 - 5s - loss: 0.5043 - accuracy: 0.7696  
Epoch 4/20

278/278 - 5s - loss: 0.7906 - accuracy: 0.7393  
Epoch 4/20  
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
Epoch 1/20  
278/278 - 6s - loss: 7.4403 - accuracy: 0.4860  
Epoch 5/20  
278/278 - 6s - loss: 0.5049 - accuracy: 0.7758  
Epoch 5/20  
278/278 - 5s - loss: 0.3267 - accuracy: 0.9788  
Epoch 5/20  
278/278 - 6s - loss: 0.5748 - accuracy: 0.7070  
Epoch 5/20  
278/278 - 6s - loss: 3.7921 - accuracy: 0.7216  
Epoch 5/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 5/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 5/20  
278/278 - 5s - loss: 0.6376 - accuracy: 0.7534  
Epoch 5/20  
278/278 - 6s - loss: 0.5024 - accuracy: 0.7713  
Epoch 5/20  
278/278 - 6s - loss: 0.3302 - accuracy: 0.9786  
Epoch 2/20  
278/278 - 6s - loss: 6.8521 - accuracy: 0.5153  
Epoch 6/20  
278/278 - 5s - loss: 0.5216 - accuracy: 0.7707  
Epoch 6/20  
278/278 - 5s - loss: 0.3267 - accuracy: 0.9788  
Epoch 6/20  
278/278 - 5s - loss: 0.5486 - accuracy: 0.7368  
Epoch 6/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 6/20  
278/278 - 6s - loss: 4.0693 - accuracy: 0.6754  
Epoch 6/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 6/20  
278/278 - 5s - loss: 0.7110 - accuracy: 0.7440  
Epoch 6/20  
278/278 - 6s - loss: 0.6043 - accuracy: 0.7556  
Epoch 6/20  
278/278 - 6s - loss: 0.3302 - accuracy: 0.9786  
Epoch 3/20  
278/278 - 5s - loss: 7.5517 - accuracy: 0.5001  
Epoch 7/20  
278/278 - 5s - loss: 0.5499 - accuracy: 0.7680  
Epoch 7/20

278/278 - 5s - loss: 0.5263 - accuracy: 0.7635  
Epoch 7/20  
278/278 - 6s - loss: 0.3267 - accuracy: 0.9788  
Epoch 7/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 7/20  
278/278 - 5s - loss: 1.5057 - accuracy: 0.6832  
Epoch 7/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 7/20  
278/278 - 5s - loss: 0.6276 - accuracy: 0.6628  
Epoch 7/20  
278/278 - 5s - loss: 0.5732 - accuracy: 0.7563  
Epoch 7/20  
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
Epoch 4/20  
278/278 - 6s - loss: 3.5535 - accuracy: 0.6247  
Epoch 8/20  
278/278 - 5s - loss: 0.5133 - accuracy: 0.7716  
Epoch 8/20  
278/278 - 6s - loss: 0.5107 - accuracy: 0.7758  
Epoch 8/20  
278/278 - 5s - loss: 0.3267 - accuracy: 0.9788  
Epoch 8/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 8/20  
278/278 - 5s - loss: 1.0698 - accuracy: 0.6680  
Epoch 8/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 8/20  
278/278 - 6s - loss: 0.5842 - accuracy: 0.7176  
Epoch 8/20  
278/278 - 6s - loss: 0.5456 - accuracy: 0.7577  
Epoch 8/20  
278/278 - 6s - loss: 0.3302 - accuracy: 0.9786  
Epoch 5/20  
278/278 - 5s - loss: 1.1956 - accuracy: 0.7212  
Epoch 9/20  
278/278 - 5s - loss: 0.4919 - accuracy: 0.7752  
Epoch 9/20  
278/278 - 5s - loss: 0.5016 - accuracy: 0.7790  
Epoch 9/20  
278/278 - 6s - loss: 0.3267 - accuracy: 0.9788  
Epoch 9/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 9/20  
278/278 - 5s - loss: 0.9913 - accuracy: 0.5865  
Epoch 9/20



278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 9/20  
278/278 - 5s - loss: 0.5405 - accuracy: 0.7508  
Epoch 9/20  
278/278 - 6s - loss: 0.8641 - accuracy: 0.7222  
Epoch 9/20  
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
Epoch 6/20  
278/278 - 5s - loss: 0.5919 - accuracy: 0.7623  
Epoch 10/20  
278/278 - 5s - loss: 0.4907 - accuracy: 0.7778  
Epoch 10/20  
278/278 - 5s - loss: 0.5021 - accuracy: 0.7803  
Epoch 10/20  
278/278 - 6s - loss: 0.3267 - accuracy: 0.9788  
Epoch 10/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 10/20  
278/278 - 5s - loss: 0.8271 - accuracy: 0.6315  
Epoch 10/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 10/20  
278/278 - 5s - loss: 0.5244 - accuracy: 0.7646  
Epoch 10/20  
278/278 - 5s - loss: 0.5516 - accuracy: 0.7587  
Epoch 10/20  
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
Epoch 7/20  
278/278 - 5s - loss: 0.5640 - accuracy: 0.7672  
Epoch 11/20  
278/278 - 6s - loss: 0.4920 - accuracy: 0.7788  
Epoch 11/20  
278/278 - 5s - loss: 0.4919 - accuracy: 0.7848  
Epoch 11/20  
278/278 - 5s - loss: 0.3267 - accuracy: 0.9788  
Epoch 11/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 11/20  
278/278 - 5s - loss: 0.7432 - accuracy: 0.6403  
Epoch 11/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 11/20  
278/278 - 6s - loss: 0.5212 - accuracy: 0.7694  
Epoch 11/20  
278/278 - 6s - loss: 0.6289 - accuracy: 0.7470  
Epoch 11/20  
278/278 - 6s - loss: 0.3302 - accuracy: 0.9786  
Epoch 8/20

278/278 - 5s - loss: 1.2316 - accuracy: 0.6984  
Epoch 12/20  
278/278 - 5s - loss: 0.4832 - accuracy: 0.7763  
Epoch 12/20  
278/278 - 5s - loss: 0.4896 - accuracy: 0.7833  
Epoch 12/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 12/20  
278/278 - 6s - loss: 0.3267 - accuracy: 0.9788  
Epoch 12/20  
278/278 - 5s - loss: 0.6431 - accuracy: 0.6890  
Epoch 12/20  
278/278 - 5s - loss: 0.5154 - accuracy: 0.7716  
Epoch 12/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 12/20  
278/278 - 6s - loss: 0.6174 - accuracy: 0.7445  
Epoch 12/20  
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
Epoch 9/20  
278/278 - 6s - loss: 0.5634 - accuracy: 0.7631  
Epoch 13/20  
278/278 - 5s - loss: 0.5149 - accuracy: 0.7614  
Epoch 13/20  
278/278 - 6s - loss: 0.4922 - accuracy: 0.7842  
Epoch 13/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 13/20  
278/278 - 6s - loss: 0.6245 - accuracy: 0.7250  
Epoch 13/20  
278/278 - 6s - loss: 0.3267 - accuracy: 0.9788  
Epoch 13/20  
278/278 - 5s - loss: 0.5191 - accuracy: 0.7693  
Epoch 13/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 13/20  
278/278 - 6s - loss: 0.5700 - accuracy: 0.7618  
Epoch 13/20  
278/278 - 6s - loss: 0.3302 - accuracy: 0.9786  
Epoch 10/20  
278/278 - 5s - loss: 0.5439 - accuracy: 0.7612  
Epoch 14/20  
278/278 - 5s - loss: 0.5106 - accuracy: 0.7800  
Epoch 14/20  
278/278 - 5s - loss: 0.4906 - accuracy: 0.7844  
Epoch 14/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 14/20

278/278 - 5s - loss: 0.5572 - accuracy: 0.7436  
Epoch 14/20  
278/278 - 5s - loss: 0.3267 - accuracy: 0.9788  
Epoch 14/20  
278/278 - 5s - loss: 0.5058 - accuracy: 0.7781  
Epoch 14/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 14/20  
278/278 - 5s - loss: 0.5608 - accuracy: 0.7554  
Epoch 14/20  
278/278 - 6s - loss: 0.3302 - accuracy: 0.9786  
Epoch 11/20  
278/278 - 5s - loss: 0.5358 - accuracy: 0.7663  
Epoch 15/20  
278/278 - 5s - loss: 0.6862 - accuracy: 0.7455  
Epoch 15/20  
278/278 - 5s - loss: 0.6407 - accuracy: 0.7459  
Epoch 15/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 15/20  
278/278 - 6s - loss: 0.5532 - accuracy: 0.7338  
Epoch 15/20  
278/278 - 5s - loss: 0.3267 - accuracy: 0.9788  
Epoch 15/20  
278/278 - 5s - loss: 0.4980 - accuracy: 0.7797  
Epoch 15/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 15/20  
278/278 - 6s - loss: 0.5292 - accuracy: 0.7612  
Epoch 15/20  
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
Epoch 12/20  
278/278 - 5s - loss: 0.5330 - accuracy: 0.7702  
Epoch 16/20  
278/278 - 6s - loss: 0.5410 - accuracy: 0.7568  
Epoch 16/20  
278/278 - 5s - loss: 0.5556 - accuracy: 0.7401  
Epoch 16/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 16/20  
278/278 - 6s - loss: 0.5327 - accuracy: 0.7492  
Epoch 16/20  
278/278 - 6s - loss: 0.3267 - accuracy: 0.9788  
Epoch 16/20  
278/278 - 5s - loss: 0.5640 - accuracy: 0.7670  
Epoch 16/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 16/20

278/278 - 5s - loss: 0.5282 - accuracy: 0.7616  
Epoch 16/20  
278/278 - 6s - loss: 0.3302 - accuracy: 0.9786  
Epoch 13/20  
278/278 - 5s - loss: 0.5311 - accuracy: 0.7702  
Epoch 17/20  
278/278 - 5s - loss: 0.5460 - accuracy: 0.7525  
Epoch 17/20  
278/278 - 5s - loss: 0.5289 - accuracy: 0.7637  
Epoch 17/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 17/20  
278/278 - 5s - loss: 0.5258 - accuracy: 0.7508  
Epoch 17/20  
278/278 - 6s - loss: 0.3267 - accuracy: 0.9788  
Epoch 17/20  
278/278 - 6s - loss: 0.6451 - accuracy: 0.7550  
Epoch 17/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 17/20  
278/278 - 6s - loss: 0.6593 - accuracy: 0.7506  
Epoch 17/20  
278/278 - 6s - loss: 0.3302 - accuracy: 0.9786  
Epoch 14/20  
278/278 - 5s - loss: 0.5297 - accuracy: 0.7711  
Epoch 18/20  
278/278 - 6s - loss: 0.5471 - accuracy: 0.7565  
Epoch 18/20  
278/278 - 5s - loss: 0.5162 - accuracy: 0.7756  
Epoch 18/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 18/20  
278/278 - 6s - loss: 0.5264 - accuracy: 0.7511  
Epoch 18/20  
278/278 - 5s - loss: 0.3267 - accuracy: 0.9788  
Epoch 18/20  
278/278 - 6s - loss: 0.9155 - accuracy: 0.7121  
Epoch 18/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 18/20  
278/278 - 5s - loss: 1.5077 - accuracy: 0.6734  
Epoch 18/20  
278/278 - 6s - loss: 0.3302 - accuracy: 0.9786  
Epoch 15/20  
278/278 - 5s - loss: 0.5525 - accuracy: 0.7677  
Epoch 19/20  
278/278 - 5s - loss: 0.5120 - accuracy: 0.7753  
Epoch 19/20

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278/278 - 5s - loss: 0.5475 - accuracy: 0.7600
Epoch 19/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 19/20
278/278 - 5s - loss: 0.3267 - accuracy: 0.9788
Epoch 19/20
278/278 - 6s - loss: 0.5463 - accuracy: 0.7416
Epoch 19/20
278/278 - 5s - loss: 0.5993 - accuracy: 0.7437
Epoch 19/20
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785
Epoch 19/20
278/278 - 5s - loss: 0.6088 - accuracy: 0.7403
Epoch 16/20
278/278 - 5s - loss: 0.5321 - accuracy: 0.7698
Epoch 19/20
278/278 - 6s - loss: 0.3302 - accuracy: 0.9786
Epoch 20/20
278/278 - 5s - loss: 0.5498 - accuracy: 0.7595

2022-03-05 13:56:05.563400: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 20/20
278/278 - 6s - loss: 0.5362 - accuracy: 0.7590

2022-03-05 13:56:05.824520: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 20/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785

2022-03-05 13:56:06.858475: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 20/20
278/278 - 5s - loss: 0.3267 - accuracy: 0.9788

2022-03-05 13:56:07.155513: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

139/139 - 2s - loss: 0.5333 - accuracy: 0.8245
Epoch 20/20
278/278 - 5s - loss: 0.5179 - accuracy: 0.7582
Epoch 20/20
278/278 - 5s - loss: 0.5696 - accuracy: 0.7537

2022-03-05 13:56:07.538573: I

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tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

139/139 - 2s - loss: 0.5087 - accuracy: 0.8258
Epoch 20/20
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785
Epoch 20/20
278/278 - 5s - loss: 0.5449 - accuracy: 0.7566

2022-03-05 13:56:07.869026: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:56:08.104029: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:56:08.172312: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

139/139 - 2s - loss: 15.4151 - accuracy: 2.2533e-04
Epoch 17/20
278/278 - 4s - loss: 0.5310 - accuracy: 0.7687
139/139 - 2s - loss: 15.3302 - accuracy: 0.0050
Epoch 20/20
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786
139/139 - 1s - loss: 0.6279 - accuracy: 0.7492

2022-03-05 13:56:08.933138: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:56:08.984555: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

139/139 - 1s - loss: 0.7371 - accuracy: 0.8317
139/139 - 1s - loss: 0.0000e+00 - accuracy: 1.0000
139/139 - 1s - loss: 0.5257 - accuracy: 0.8522

2022-03-05 13:56:09.245037: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:56:09.528846: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:56:09.746908: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:56:09.938539: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

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139/139 - 1s - loss: 15.3165 - accuracy: 0.0061

2022-03-05 13:56:10.017756: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:56:10.153014: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 18/20
278/278 - 3s - loss: 3.7170 - accuracy: 0.5771
Epoch 1/20
278/278 - 5s - loss: 1.1353 - accuracy: 0.9134
Epoch 1/20
278/278 - 5s - loss: 2.2264 - accuracy: 0.6916
Epoch 1/20
278/278 - 5s - loss: 5.1606 - accuracy: 0.6317
Epoch 1/20
278/278 - 5s - loss: 0.3426 - accuracy: 0.9754
Epoch 1/20
278/278 - 5s - loss: 4.8394 - accuracy: 0.6394
Epoch 1/20
278/278 - 5s - loss: 1.8989 - accuracy: 0.6504
Epoch 1/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 19/20
278/278 - 4s - loss: 0.6553 - accuracy: 0.6078
Epoch 2/20
278/278 - 4s - loss: 0.3320 - accuracy: 0.9785
Epoch 2/20
278/278 - 5s - loss: 0.6012 - accuracy: 0.7491
Epoch 2/20
278/278 - 4s - loss: 4.6713 - accuracy: 0.6707
Epoch 2/20
278/278 - 4s - loss: 5.0580 - accuracy: 0.6430
Epoch 2/20
278/278 - 5s - loss: 0.3118 - accuracy: 0.9792
Epoch 2/20
278/278 - 4s - loss: 1.1091 - accuracy: 0.6894
Epoch 2/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 20/20
278/278 - 4s - loss: 0.6113 - accuracy: 0.6528

2022-03-05 13:56:20.721161: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 3/20
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785

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Epoch 3/20  
278/278 - 4s - loss: 0.5808 - accuracy: 0.7534  
139/139 - 2s - loss: 0.5854 - accuracy: 0.7569  
Epoch 3/20  
278/278 - 4s - loss: 4.5981 - accuracy: 0.6816  
Epoch 3/20  
278/278 - 4s - loss: 0.3197 - accuracy: 0.9793  
Epoch 3/20  
278/278 - 4s - loss: 3.9449 - accuracy: 0.7079  
Epoch 3/20  
278/278 - 4s - loss: 0.7062 - accuracy: 0.7240  
Epoch 3/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 4/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 4/20  
278/278 - 4s - loss: 4.4200 - accuracy: 0.6919  
Epoch 4/20  
278/278 - 4s - loss: 0.5413 - accuracy: 0.7569  
Epoch 4/20  
278/278 - 4s - loss: 0.3166 - accuracy: 0.9793  
Epoch 4/20  
278/278 - 4s - loss: 3.8507 - accuracy: 0.7016  
Epoch 4/20  
278/278 - 4s - loss: 2.6683 - accuracy: 0.6359  
Epoch 4/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 5/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 5/20  
278/278 - 4s - loss: 5.2329 - accuracy: 0.6420  
Epoch 5/20  
278/278 - 4s - loss: 0.5347 - accuracy: 0.7609  
Epoch 5/20  
278/278 - 4s - loss: 0.3232 - accuracy: 0.9781  
Epoch 5/20  
278/278 - 4s - loss: 6.3043 - accuracy: 0.5803  
Epoch 5/20  
278/278 - 4s - loss: 0.8270 - accuracy: 0.6948  
Epoch 5/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 6/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 6/20  
278/278 - 4s - loss: 7.0176 - accuracy: 0.5362  
Epoch 6/20  
278/278 - 4s - loss: 0.5369 - accuracy: 0.7461  
Epoch 6/20



278/278 - 4s - loss: 0.3277 - accuracy: 0.9783  
Epoch 6/20  
278/278 - 4s - loss: 4.8874 - accuracy: 0.6523  
Epoch 6/20  
278/278 - 4s - loss: 0.5491 - accuracy: 0.7502  
Epoch 6/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 7/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 7/20  
278/278 - 4s - loss: 0.3268 - accuracy: 0.9787  
Epoch 7/20  
278/278 - 4s - loss: 7.6246 - accuracy: 0.5000  
Epoch 7/20  
278/278 - 4s - loss: 0.5678 - accuracy: 0.7501  
Epoch 7/20  
278/278 - 4s - loss: 6.3350 - accuracy: 0.5402  
Epoch 7/20  
278/278 - 4s - loss: 0.5392 - accuracy: 0.7697  
Epoch 7/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 8/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 8/20  
278/278 - 4s - loss: 0.3233 - accuracy: 0.9789  
Epoch 8/20  
278/278 - 4s - loss: 7.6246 - accuracy: 0.5000  
Epoch 8/20  
278/278 - 4s - loss: 0.5695 - accuracy: 0.7548  
Epoch 8/20  
278/278 - 4s - loss: 3.5615 - accuracy: 0.6323  
Epoch 8/20  
278/278 - 4s - loss: 0.5342 - accuracy: 0.7721  
Epoch 8/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 9/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 9/20  
278/278 - 4s - loss: 0.3253 - accuracy: 0.9788  
Epoch 9/20  
278/278 - 4s - loss: 7.6246 - accuracy: 0.5000  
Epoch 9/20  
278/278 - 4s - loss: 2.3530 - accuracy: 0.6628  
Epoch 9/20  
278/278 - 4s - loss: 0.5786 - accuracy: 0.7241  
Epoch 9/20  
278/278 - 4s - loss: 0.5720 - accuracy: 0.7666  
Epoch 9/20

278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 10/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 10/20  
278/278 - 4s - loss: 0.3252 - accuracy: 0.9788  
Epoch 10/20  
278/278 - 4s - loss: 7.6246 - accuracy: 0.5000  
Epoch 10/20  
278/278 - 4s - loss: 1.7213 - accuracy: 0.6788  
Epoch 10/20  
278/278 - 4s - loss: 0.5678 - accuracy: 0.7480  
Epoch 10/20  
278/278 - 4s - loss: 0.5176 - accuracy: 0.7649  
Epoch 10/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 11/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 11/20  
278/278 - 4s - loss: 0.3441 - accuracy: 0.9761  
Epoch 11/20  
278/278 - 4s - loss: 7.6246 - accuracy: 0.5000  
Epoch 11/20  
278/278 - 4s - loss: 1.5528 - accuracy: 0.5864  
Epoch 11/20  
278/278 - 4s - loss: 0.5318 - accuracy: 0.7678  
Epoch 11/20  
278/278 - 4s - loss: 0.5978 - accuracy: 0.7281  
Epoch 11/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 12/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 12/20  
278/278 - 4s - loss: 0.3140 - accuracy: 0.9790  
Epoch 12/20  
278/278 - 4s - loss: 7.6246 - accuracy: 0.5000  
Epoch 12/20  
278/278 - 4s - loss: 0.9556 - accuracy: 0.6089  
Epoch 12/20  
278/278 - 4s - loss: 0.5659 - accuracy: 0.7448  
Epoch 12/20  
278/278 - 4s - loss: 0.5183 - accuracy: 0.7630  
Epoch 12/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 13/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 13/20  
278/278 - 4s - loss: 0.3257 - accuracy: 0.9779  
Epoch 13/20

278/278 - 4s - loss: 7.6246 - accuracy: 0.5000  
Epoch 13/20  
278/278 - 4s - loss: 0.8171 - accuracy: 0.5997  
Epoch 13/20  
278/278 - 4s - loss: 0.5263 - accuracy: 0.7651  
Epoch 13/20  
278/278 - 4s - loss: 0.5279 - accuracy: 0.7563  
Epoch 13/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 14/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 14/20  
278/278 - 4s - loss: 0.3153 - accuracy: 0.9786  
Epoch 14/20  
278/278 - 4s - loss: 7.6246 - accuracy: 0.5000  
Epoch 14/20  
278/278 - 4s - loss: 0.7727 - accuracy: 0.6320  
Epoch 14/20  
278/278 - 4s - loss: 0.5131 - accuracy: 0.7729  
Epoch 14/20  
278/278 - 4s - loss: 0.5412 - accuracy: 0.7443  
Epoch 14/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 15/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 15/20  
278/278 - 4s - loss: 0.3155 - accuracy: 0.9783  
Epoch 15/20  
278/278 - 4s - loss: 7.6246 - accuracy: 0.5000  
Epoch 15/20  
278/278 - 4s - loss: 0.7423 - accuracy: 0.6296  
Epoch 15/20  
278/278 - 4s - loss: 0.5061 - accuracy: 0.7721  
Epoch 15/20  
278/278 - 4s - loss: 0.5220 - accuracy: 0.7690  
Epoch 15/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 16/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 16/20  
278/278 - 4s - loss: 0.3251 - accuracy: 0.9753  
Epoch 16/20  
278/278 - 4s - loss: 7.6246 - accuracy: 0.5000  
Epoch 16/20  
278/278 - 4s - loss: 0.7036 - accuracy: 0.6673  
Epoch 16/20  
278/278 - 4s - loss: 0.5018 - accuracy: 0.7782  
Epoch 16/20

278/278 - 4s - loss: 0.5272 - accuracy: 0.7589  
Epoch 16/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 17/20  
278/278 - 4s - loss: 0.3137 - accuracy: 0.9776  
Epoch 17/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 17/20  
278/278 - 4s - loss: 7.6246 - accuracy: 0.5000  
Epoch 17/20  
278/278 - 4s - loss: 0.6581 - accuracy: 0.6567  
Epoch 17/20  
278/278 - 4s - loss: 0.5176 - accuracy: 0.7683  
Epoch 17/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 17/20  
278/278 - 4s - loss: 0.5191 - accuracy: 0.7674  
Epoch 18/20  
278/278 - 4s - loss: 0.2988 - accuracy: 0.9788  
Epoch 18/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 18/20  
278/278 - 4s - loss: 7.6246 - accuracy: 0.5000  
Epoch 18/20  
278/278 - 4s - loss: 0.6276 - accuracy: 0.6569  
Epoch 18/20  
278/278 - 4s - loss: 0.6774 - accuracy: 0.7369  
Epoch 18/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 18/20  
278/278 - 4s - loss: 0.5186 - accuracy: 0.7627  
Epoch 19/20  
278/278 - 4s - loss: 0.2971 - accuracy: 0.9792  
Epoch 19/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 19/20  
278/278 - 4s - loss: 7.6246 - accuracy: 0.5000  
Epoch 19/20  
278/278 - 4s - loss: 0.5971 - accuracy: 0.6986  
Epoch 19/20  
278/278 - 4s - loss: 0.5519 - accuracy: 0.7609  
Epoch 19/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 19/20  
278/278 - 4s - loss: 0.5420 - accuracy: 0.7562  
Epoch 20/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
Epoch 20/20

```

278/278 - 4s - loss: 0.2966 - accuracy: 0.9790

2022-03-05 13:57:27.608829: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:57:27.619655: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 20/20
278/278 - 4s - loss: 7.6246 - accuracy: 0.5000

2022-03-05 13:57:28.187965: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 20/20
278/278 - 4s - loss: 0.5631 - accuracy: 0.7392
139/139 - 1s - loss: 13.4663 - accuracy: 0.0448

2022-03-05 13:57:28.686912: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

139/139 - 1s - loss: 15.4216 - accuracy: 2.2533e-04
Epoch 20/20
278/278 - 4s - loss: 0.5300 - accuracy: 0.7686

2022-03-05 13:57:28.964719: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 20/20
278/278 - 3s - loss: 0.3319 - accuracy: 0.9785
139/139 - 1s - loss: 14.5930 - accuracy: 0.0430
Epoch 20/20
278/278 - 3s - loss: 0.5226 - accuracy: 0.7695

2022-03-05 13:57:29.266117: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:57:29.338405: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

139/139 - 1s - loss: 0.5341 - accuracy: 0.8711
139/139 - 1s - loss: 0.5566 - accuracy: 0.8218
139/139 - 1s - loss: 15.4249 - accuracy: 0.0000e+00
139/139 - 1s - loss: 0.5269 - accuracy: 0.8558
Epoch 1/20

2022-03-05 13:57:30.263183: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]

```

Plugin optimizer for device\_type GPU is enabled.

```
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 2/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 3/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 4/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 5/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 6/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 7/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 8/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 9/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 10/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 11/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 12/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 13/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 14/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 15/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 16/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 17/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 18/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 19/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
Epoch 20/20
417/417 - 2s - loss: 9.9474 - accuracy: 0.3477
```

```
[32]: # summarize results
print("Best: %f using %s" % (grid_result.best_score_, grid_result.best_params_))
means = grid_result.cv_results_['mean_test_score']
stds = grid_result.cv_results_['std_test_score']
params = grid_result.cv_results_['params']
for mean, stdev, param in zip(means, stds, params):
```

```
print("%f (%f) with: %r" % (mean, stdev, param))
```

```
Best: 0.609809 using {'learn_rate': 0.1, 'momentum': 0.0}
0.275424 (0.359506) with: {'learn_rate': 0.01, 'momentum': 0.0}
0.564068 (0.398805) with: {'learn_rate': 0.01, 'momentum': 0.1}
0.542662 (0.384532) with: {'learn_rate': 0.01, 'momentum': 0.2}
0.609809 (0.433657) with: {'learn_rate': 0.1, 'momentum': 0.0}
0.608683 (0.436081) with: {'learn_rate': 0.1, 'momentum': 0.1}
0.535827 (0.376937) with: {'learn_rate': 0.1, 'momentum': 0.2}
0.529593 (0.375563) with: {'learn_rate': 0.2, 'momentum': 0.0}
0.314556 (0.382712) with: {'learn_rate': 0.2, 'momentum': 0.1}
0.564293 (0.399524) with: {'learn_rate': 0.2, 'momentum': 0.2}
```

### Tune Network Weight Initialization

```
[33]: # define the grid search parameters
init_mode = ['uniform', 'normal', 'zero']
param_grid = dict(init_mode=init_mode)
grid = GridSearchCV(estimator=model, param_grid=param_grid, n_jobs=-1, cv=3)
grid_result = grid.fit(X_train, y_train)
```

```
2022-03-05 13:58:06.835438: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:58:06.853796: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:58:06.854712: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:58:06.860913: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:58:06.862330: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:58:06.864238: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:58:06.872062: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:58:06.886336: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:58:06.905786: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
```

Epoch 1/20  
278/278 - 5s - loss: 5.3322 - accuracy: 0.6070  
Epoch 1/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 1/20  
278/278 - 5s - loss: 4.2411 - accuracy: 0.5412  
Epoch 1/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 1/20  
278/278 - 5s - loss: 0.3981 - accuracy: 0.9617  
Epoch 1/20  
278/278 - 5s - loss: 1.0670 - accuracy: 0.6985  
Epoch 1/20  
278/278 - 5s - loss: 1.0513 - accuracy: 0.9273  
Epoch 1/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 1/20  
278/278 - 5s - loss: 7.6198 - accuracy: 0.5002  
Epoch 2/20  
278/278 - 5s - loss: 0.3269 - accuracy: 0.9787  
Epoch 2/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 2/20  
278/278 - 5s - loss: 6.3928 - accuracy: 0.5513  
Epoch 2/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 2/20  
278/278 - 5s - loss: 3.0718 - accuracy: 0.6534  
Epoch 2/20  
278/278 - 5s - loss: 0.6450 - accuracy: 0.7523  
Epoch 2/20  
278/278 - 5s - loss: 0.3367 - accuracy: 0.9777  
Epoch 2/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 2/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 3/20  
278/278 - 5s - loss: 0.3287 - accuracy: 0.9786  
Epoch 3/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 3/20  
278/278 - 5s - loss: 0.5265 - accuracy: 0.7601  
Epoch 3/20  
278/278 - 5s - loss: 2.7335 - accuracy: 0.6315  
Epoch 3/20  
278/278 - 5s - loss: 0.3327 - accuracy: 0.9781  
Epoch 3/20  
278/278 - 5s - loss: 0.5567 - accuracy: 0.7547



Epoch 3/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 3/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 3/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 4/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 4/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 4/20  
278/278 - 5s - loss: 0.6052 - accuracy: 0.7306  
Epoch 4/20  
278/278 - 5s - loss: 0.3324 - accuracy: 0.9783  
Epoch 4/20  
278/278 - 5s - loss: 0.5035 - accuracy: 0.7676  
Epoch 4/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 4/20  
278/278 - 5s - loss: 0.5432 - accuracy: 0.7599  
Epoch 4/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 4/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 5/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 5/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 5/20  
278/278 - 5s - loss: 0.3322 - accuracy: 0.9783  
Epoch 5/20  
278/278 - 5s - loss: 0.5072 - accuracy: 0.7707  
Epoch 5/20  
278/278 - 5s - loss: 2.2892 - accuracy: 0.7021  
Epoch 5/20  
278/278 - 5s - loss: 7.9724 - accuracy: 0.4820  
Epoch 5/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 5/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 5/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 6/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 6/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 6/20  
278/278 - 5s - loss: 0.3321 - accuracy: 0.9784

Epoch 6/20  
278/278 - 5s - loss: 7.6920 - accuracy: 0.5011  
Epoch 6/20  
278/278 - 5s - loss: 7.9416 - accuracy: 0.4839  
Epoch 6/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 6/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 6/20  
278/278 - 5s - loss: 0.6928 - accuracy: 0.7115  
Epoch 6/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 7/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 7/20  
278/278 - 5s - loss: 0.3320 - accuracy: 0.9784  
Epoch 7/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 7/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 7/20  
278/278 - 5s - loss: 6.5921 - accuracy: 0.5600  
Epoch 7/20  
278/278 - 5s - loss: 6.9275 - accuracy: 0.5427  
Epoch 7/20  
278/278 - 5s - loss: 0.5891 - accuracy: 0.7145  
Epoch 7/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 7/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 8/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 8/20  
278/278 - 5s - loss: 0.3320 - accuracy: 0.9784  
Epoch 8/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 8/20  
278/278 - 5s - loss: 5.1637 - accuracy: 0.6485  
Epoch 8/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 8/20  
278/278 - 5s - loss: 5.4288 - accuracy: 0.6107  
Epoch 8/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 8/20  
278/278 - 5s - loss: 0.7162 - accuracy: 0.6636  
Epoch 8/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785

Epoch 9/20  
 278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 9/20  
 278/278 - 5s - loss: 0.3320 - accuracy: 0.9784  
 Epoch 9/20  
 278/278 - 5s - loss: 6.4736 - accuracy: 0.5704  
 Epoch 9/20  
 278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
 Epoch 9/20  
 278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
 Epoch 9/20  
 278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
 Epoch 9/20  
 278/278 - 5s - loss: 0.5464 - accuracy: 0.7686  
 Epoch 9/20  
 278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 9/20  
 278/278 - 5s - loss: 6.3847 - accuracy: 0.5676  
 Epoch 10/20  
 278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 10/20  
 278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 10/20  
 278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
 Epoch 10/20  
 278/278 - 5s - loss: 5.9151 - accuracy: 0.6012  
 Epoch 10/20  
 278/278 - 5s - loss: 0.5787 - accuracy: 0.7136  
 Epoch 10/20  
 278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
 Epoch 10/20  
 278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
 Epoch 10/20  
 278/278 - 5s - loss: 5.2395 - accuracy: 0.5933  
 Epoch 10/20  
 278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 11/20  
 278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 11/20  
 278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 11/20  
 278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
 Epoch 11/20  
 278/278 - 5s - loss: 5.0200 - accuracy: 0.6518  
 Epoch 11/20  
 278/278 - 5s - loss: 0.5491 - accuracy: 0.7200  
 Epoch 11/20  
 278/278 - 5s - loss: 8.0444 - accuracy: 0.4785

Epoch 11/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 11/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 11/20  
278/278 - 5s - loss: 3.1869 - accuracy: 0.6491  
Epoch 12/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 12/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 12/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 12/20  
278/278 - 5s - loss: 5.7307 - accuracy: 0.6130  
Epoch 12/20  
278/278 - 5s - loss: 0.5814 - accuracy: 0.7347  
Epoch 12/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 12/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 12/20  
278/278 - 5s - loss: 0.5847 - accuracy: 0.7446  
Epoch 12/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 13/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 13/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 13/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 13/20  
278/278 - 5s - loss: 6.0281 - accuracy: 0.5947  
Epoch 13/20  
278/278 - 5s - loss: 0.5143 - accuracy: 0.7639  
Epoch 13/20  
278/278 - 5s - loss: 0.5498 - accuracy: 0.7668  
Epoch 13/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 13/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 13/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 14/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 14/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 14/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785

Epoch 14/20  
278/278 - 5s - loss: 7.3020 - accuracy: 0.5210  
Epoch 14/20  
278/278 - 5s - loss: 0.5427 - accuracy: 0.7671  
Epoch 14/20  
278/278 - 5s - loss: 0.5149 - accuracy: 0.7559  
Epoch 14/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 14/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 14/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 15/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 15/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 15/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 15/20  
278/278 - 5s - loss: 7.3019 - accuracy: 0.5211  
Epoch 15/20  
278/278 - 5s - loss: 0.5082 - accuracy: 0.7666  
Epoch 15/20  
278/278 - 5s - loss: 0.5413 - accuracy: 0.7688  
Epoch 15/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 15/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 15/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 16/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 16/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 16/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 16/20  
278/278 - 5s - loss: 0.5394 - accuracy: 0.7724  
Epoch 16/20  
278/278 - 5s - loss: 7.3019 - accuracy: 0.5211  
Epoch 16/20  
278/278 - 5s - loss: 0.4879 - accuracy: 0.7763  
Epoch 16/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 16/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 16/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785

Epoch 17/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 17/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 17/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 17/20  
278/278 - 5s - loss: 7.3019 - accuracy: 0.5211  
Epoch 17/20  
278/278 - 5s - loss: 0.4910 - accuracy: 0.7731  
Epoch 17/20  
278/278 - 5s - loss: 0.5653 - accuracy: 0.7595  
Epoch 17/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 17/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 17/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 18/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 18/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 18/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 18/20  
278/278 - 5s - loss: 0.4851 - accuracy: 0.7726  
Epoch 18/20  
278/278 - 5s - loss: 7.3019 - accuracy: 0.5211  
Epoch 18/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 18/20  
278/278 - 5s - loss: 0.5166 - accuracy: 0.7707  
Epoch 18/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 18/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 19/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 19/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
Epoch 19/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 19/20  
278/278 - 5s - loss: 0.4898 - accuracy: 0.7806  
Epoch 19/20  
278/278 - 5s - loss: 7.3019 - accuracy: 0.5211  
Epoch 19/20  
278/278 - 5s - loss: 0.5468 - accuracy: 0.7651

Epoch 19/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 19/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 19/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 20/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
  
2022-03-05 13:59:43.852630: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
  
Epoch 20/20  
278/278 - 5s - loss: 7.7125 - accuracy: 0.5000  
  
2022-03-05 13:59:44.739099: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 13:59:44.938879: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
  
Epoch 20/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 20/20  
278/278 - 5s - loss: 0.5010 - accuracy: 0.7696  
Epoch 20/20  
278/278 - 5s - loss: 7.3020 - accuracy: 0.5211  
139/139 - 2s - loss: 15.4073 - accuracy: 0.0000e+00  
Epoch 20/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
  
2022-03-05 13:59:45.440456: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 13:59:45.466658: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 13:59:45.624019: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
  
Epoch 20/20  
278/278 - 5s - loss: 7.5174 - accuracy: 0.5018  
Epoch 20/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 20/20  
278/278 - 4s - loss: 0.3319 - accuracy: 0.9785  
  
2022-03-05 13:59:45.663803: I

```

tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:59:45.782247: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 13:59:45.849093: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

139/139 - 1s - loss: 0.6638 - accuracy: 0.9570
139/139 - 1s - loss: 15.2644 - accuracy: 0.0092
139/139 - 1s - loss: 0.5594 - accuracy: 0.7828
139/139 - 1s - loss: 15.2466 - accuracy: 0.0000e+00
139/139 - 1s - loss: 14.5930 - accuracy: 0.0430
139/139 - 1s - loss: 14.5930 - accuracy: 0.0430
139/139 - 1s - loss: 0.0000e+00 - accuracy: 1.0000
139/139 - 1s - loss: 15.4249 - accuracy: 0.0000e+00
Epoch 1/20

2022-03-05 13:59:47.132423: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 2/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 3/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 4/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 5/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 6/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 7/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 8/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 9/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 10/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 11/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 12/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 13/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 14/20

```



```

417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 15/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 16/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 17/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 18/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 19/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523
Epoch 20/20
417/417 - 2s - loss: 5.3629 - accuracy: 0.6523

```

```

[34]: # summarize results
print("Best: %f using %s" % (grid_result.best_score_, grid_result.best_params_))
means = grid_result.cv_results_['mean_test_score']
stds = grid_result.cv_results_['std_test_score']
params = grid_result.cv_results_['params']
for mean, stdev, param in zip(means, stds, params):
    print("%f (%f) with: %r" % (mean, stdev, param))

```

```

Best: 0.652321 using {'init_mode': 'zero'}
0.014346 (0.020288) with: {'init_mode': 'uniform'}
0.278354 (0.356954) with: {'init_mode': 'normal'}
0.652321 (0.461595) with: {'init_mode': 'zero'}

```

### Tune the Neuron Activation Function

```

[35]: # define the grid search parameters
activation = ['relu', 'tanh', 'sigmoid', 'linear']
param_grid = dict(activation=activation)
grid = GridSearchCV(estimator=model, param_grid=param_grid, n_jobs=-1, cv=3)
grid_result = grid.fit(X_train, y_train)

```

```

2022-03-05 14:00:38.253310: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:00:38.265451: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:00:38.282034: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:00:38.288662: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:00:38.291459: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]

```

Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 14:00:38.293108: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 14:00:38.293139: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 14:00:38.302570: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 14:00:38.339357: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.  
2022-03-05 14:00:38.367154: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.

Epoch 1/20  
278/278 - 6s - loss: 5.2307 - accuracy: 0.5389  
Epoch 1/20  
278/278 - 6s - loss: 0.6178 - accuracy: 0.6920  
Epoch 1/20  
278/278 - 6s - loss: 0.6269 - accuracy: 0.6947  
Epoch 1/20  
278/278 - 6s - loss: 0.1863 - accuracy: 0.9784  
Epoch 1/20  
278/278 - 6s - loss: 7.6336 - accuracy: 0.4988  
Epoch 1/20  
278/278 - 6s - loss: 6.9598 - accuracy: 0.5428  
Epoch 1/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 1/20  
278/278 - 6s - loss: 0.6508 - accuracy: 0.6511  
Epoch 1/20  
278/278 - 6s - loss: 0.3307 - accuracy: 0.9783  
Epoch 1/20  
278/278 - 6s - loss: 0.4097 - accuracy: 0.9339  
Epoch 2/20  
278/278 - 5s - loss: 0.1088 - accuracy: 0.9785  
Epoch 2/20  
278/278 - 5s - loss: 0.5505 - accuracy: 0.7445  
Epoch 2/20  
278/278 - 5s - loss: 0.5823 - accuracy: 0.7260  
Epoch 2/20  
278/278 - 5s - loss: 6.4638 - accuracy: 0.5774  
Epoch 2/20  
278/278 - 5s - loss: 0.5481 - accuracy: 0.7355  
Epoch 2/20

278/278 - 5s - loss: 0.5649 - accuracy: 0.7392  
Epoch 2/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 2/20  
278/278 - 6s - loss: 7.5781 - accuracy: 0.5002  
Epoch 2/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 2/20  
278/278 - 6s - loss: 0.3221 - accuracy: 0.9788  
Epoch 3/20  
278/278 - 5s - loss: 0.1021 - accuracy: 0.9785  
Epoch 3/20  
278/278 - 5s - loss: 0.5240 - accuracy: 0.7485  
Epoch 3/20  
278/278 - 5s - loss: 7.4854 - accuracy: 0.5144  
Epoch 3/20  
278/278 - 5s - loss: 0.5342 - accuracy: 0.7470  
Epoch 3/20  
278/278 - 5s - loss: 0.5154 - accuracy: 0.7610  
Epoch 3/20  
278/278 - 5s - loss: 7.6201 - accuracy: 0.5000  
Epoch 3/20  
278/278 - 6s - loss: 0.5600 - accuracy: 0.7304  
Epoch 3/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 3/20  
278/278 - 5s - loss: 0.3222 - accuracy: 0.9789  
Epoch 3/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 4/20  
278/278 - 5s - loss: 0.0992 - accuracy: 0.9785  
Epoch 4/20  
278/278 - 5s - loss: 7.2498 - accuracy: 0.5292  
Epoch 4/20  
278/278 - 5s - loss: 0.5201 - accuracy: 0.7515  
Epoch 4/20  
278/278 - 6s - loss: 0.5067 - accuracy: 0.7538  
Epoch 4/20  
278/278 - 5s - loss: 0.5410 - accuracy: 0.7323  
Epoch 4/20  
278/278 - 6s - loss: 0.4970 - accuracy: 0.7623  
Epoch 4/20  
278/278 - 6s - loss: 7.6183 - accuracy: 0.5002  
Epoch 4/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 4/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 4/20

278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 5/20  
278/278 - 5s - loss: 0.0968 - accuracy: 0.9785  
Epoch 5/20  
278/278 - 5s - loss: 6.8038 - accuracy: 0.5573  
Epoch 5/20  
278/278 - 5s - loss: 0.5086 - accuracy: 0.7569  
Epoch 5/20  
278/278 - 5s - loss: 0.4885 - accuracy: 0.7623  
Epoch 5/20  
278/278 - 5s - loss: 0.4924 - accuracy: 0.7644  
Epoch 5/20  
278/278 - 6s - loss: 0.5182 - accuracy: 0.7425  
Epoch 5/20  
278/278 - 6s - loss: 7.6061 - accuracy: 0.4993  
Epoch 5/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 5/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 5/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 6/20  
278/278 - 5s - loss: 0.0944 - accuracy: 0.9785  
Epoch 6/20  
278/278 - 5s - loss: 6.4025 - accuracy: 0.5825  
Epoch 6/20  
278/278 - 5s - loss: 0.4770 - accuracy: 0.7687  
Epoch 6/20  
278/278 - 5s - loss: 0.4916 - accuracy: 0.7626  
Epoch 6/20  
278/278 - 5s - loss: 0.4780 - accuracy: 0.7734  
Epoch 6/20  
278/278 - 5s - loss: 0.4981 - accuracy: 0.7507  
Epoch 6/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 6/20  
278/278 - 6s - loss: 5.7689 - accuracy: 0.5167  
Epoch 6/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 6/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 7/20  
278/278 - 5s - loss: 0.0926 - accuracy: 0.9785  
Epoch 7/20  
278/278 - 5s - loss: 6.8430 - accuracy: 0.5552  
Epoch 7/20  
278/278 - 5s - loss: 0.4701 - accuracy: 0.7717  
Epoch 7/20

278/278 - 5s - loss: 0.4711 - accuracy: 0.7716  
Epoch 7/20  
278/278 - 5s - loss: 0.4907 - accuracy: 0.7561  
Epoch 7/20  
278/278 - 6s - loss: 0.4674 - accuracy: 0.7831  
Epoch 7/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 7/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 7/20  
278/278 - 6s - loss: 0.7117 - accuracy: 0.6196  
Epoch 7/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 8/20  
278/278 - 5s - loss: 0.0917 - accuracy: 0.9785  
Epoch 8/20  
278/278 - 5s - loss: 7.5791 - accuracy: 0.5083  
Epoch 8/20  
278/278 - 5s - loss: 0.4629 - accuracy: 0.7730  
Epoch 8/20  
278/278 - 5s - loss: 0.4654 - accuracy: 0.7749  
Epoch 8/20  
278/278 - 5s - loss: 0.4826 - accuracy: 0.7603  
Epoch 8/20  
278/278 - 5s - loss: 0.4666 - accuracy: 0.7767  
Epoch 8/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 8/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 8/20  
278/278 - 5s - loss: 0.6558 - accuracy: 0.6356  
Epoch 8/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 9/20  
278/278 - 5s - loss: 0.0910 - accuracy: 0.9785  
Epoch 9/20  
278/278 - 5s - loss: 6.4410 - accuracy: 0.5790  
Epoch 9/20  
278/278 - 5s - loss: 0.4562 - accuracy: 0.7743  
Epoch 9/20  
278/278 - 5s - loss: 0.4599 - accuracy: 0.7786  
Epoch 9/20  
278/278 - 5s - loss: 0.4782 - accuracy: 0.7639  
Epoch 9/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 9/20  
278/278 - 5s - loss: 0.4562 - accuracy: 0.7839  
Epoch 9/20

278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 9/20  
278/278 - 6s - loss: 0.6180 - accuracy: 0.6556  
Epoch 9/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 10/20  
278/278 - 5s - loss: 0.0899 - accuracy: 0.9785  
Epoch 10/20  
278/278 - 5s - loss: 5.7066 - accuracy: 0.6230  
Epoch 10/20  
278/278 - 5s - loss: 0.4561 - accuracy: 0.7786  
Epoch 10/20  
278/278 - 5s - loss: 0.4527 - accuracy: 0.7758  
Epoch 10/20  
278/278 - 6s - loss: 0.4705 - accuracy: 0.7702  
Epoch 10/20  
278/278 - 5s - loss: 0.5446 - accuracy: 0.7079  
Epoch 10/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 10/20  
278/278 - 5s - loss: 0.6111 - accuracy: 0.6743  
Epoch 10/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 10/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 11/20  
278/278 - 5s - loss: 0.0892 - accuracy: 0.9785  
Epoch 11/20  
278/278 - 5s - loss: 6.3547 - accuracy: 0.5849  
Epoch 11/20  
278/278 - 5s - loss: 0.4458 - accuracy: 0.7793  
Epoch 11/20  
278/278 - 5s - loss: 0.4564 - accuracy: 0.7803  
Epoch 11/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 11/20  
278/278 - 5s - loss: 0.4695 - accuracy: 0.7674  
Epoch 11/20  
278/278 - 5s - loss: 0.5161 - accuracy: 0.7480  
Epoch 11/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 11/20  
278/278 - 5s - loss: 0.5941 - accuracy: 0.6981  
Epoch 11/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 12/20  
278/278 - 5s - loss: 0.0883 - accuracy: 0.9785  
Epoch 12/20

278/278 - 5s - loss: 6.9810 - accuracy: 0.5469  
Epoch 12/20  
278/278 - 5s - loss: 0.4499 - accuracy: 0.7844  
Epoch 12/20  
278/278 - 5s - loss: 0.4430 - accuracy: 0.7831  
Epoch 12/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 12/20  
278/278 - 6s - loss: 0.4618 - accuracy: 0.7714  
Epoch 12/20  
278/278 - 6s - loss: 0.4989 - accuracy: 0.7571  
Epoch 12/20  
278/278 - 5s - loss: 0.5702 - accuracy: 0.7151  
Epoch 12/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 12/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 13/20  
278/278 - 5s - loss: 0.0870 - accuracy: 0.9785  
Epoch 13/20  
278/278 - 5s - loss: 6.9809 - accuracy: 0.5468  
Epoch 13/20  
278/278 - 5s - loss: 0.4499 - accuracy: 0.7838  
Epoch 13/20  
278/278 - 5s - loss: 0.4403 - accuracy: 0.7824  
Epoch 13/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 13/20  
278/278 - 5s - loss: 0.4578 - accuracy: 0.7744  
Epoch 13/20  
278/278 - 6s - loss: 0.4917 - accuracy: 0.7639  
Epoch 13/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 13/20  
278/278 - 6s - loss: 0.6367 - accuracy: 0.6878  
Epoch 13/20  
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785  
Epoch 14/20  
278/278 - 5s - loss: 6.9808 - accuracy: 0.5468  
Epoch 14/20  
278/278 - 6s - loss: 0.0865 - accuracy: 0.9785  
Epoch 14/20  
278/278 - 5s - loss: 0.4484 - accuracy: 0.7853  
Epoch 14/20  
278/278 - 5s - loss: 0.4389 - accuracy: 0.7841  
Epoch 14/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 14/20

278/278 - 5s - loss: 0.4541 - accuracy: 0.7749  
Epoch 14/20  
278/278 - 6s - loss: 0.4768 - accuracy: 0.7699  
Epoch 14/20  
278/278 - 5s - loss: 0.5405 - accuracy: 0.7574  
Epoch 14/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 14/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 15/20  
278/278 - 5s - loss: 0.0864 - accuracy: 0.9786  
Epoch 15/20  
278/278 - 5s - loss: 6.9794 - accuracy: 0.5469  
Epoch 15/20  
278/278 - 5s - loss: 0.4470 - accuracy: 0.7844  
Epoch 15/20  
278/278 - 5s - loss: 0.4356 - accuracy: 0.7871  
Epoch 15/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 15/20  
278/278 - 6s - loss: 0.4517 - accuracy: 0.7752  
Epoch 15/20  
278/278 - 5s - loss: 0.4700 - accuracy: 0.7741  
Epoch 15/20  
278/278 - 5s - loss: 0.5270 - accuracy: 0.7661  
Epoch 15/20  
278/278 - 6s - loss: 0.3319 - accuracy: 0.9785  
Epoch 15/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 16/20  
278/278 - 5s - loss: 6.9791 - accuracy: 0.5469  
Epoch 16/20  
278/278 - 6s - loss: 0.0852 - accuracy: 0.9789  
Epoch 16/20  
278/278 - 5s - loss: 0.4481 - accuracy: 0.7842  
Epoch 16/20  
278/278 - 5s - loss: 0.4345 - accuracy: 0.7856  
Epoch 16/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 16/20  
278/278 - 5s - loss: 0.4547 - accuracy: 0.7749  
Epoch 16/20  
278/278 - 5s - loss: 0.4657 - accuracy: 0.7740  
Epoch 16/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 16/20  
278/278 - 6s - loss: 0.5214 - accuracy: 0.7717  
Epoch 16/20



278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 17/20  
278/278 - 5s - loss: 6.9763 - accuracy: 0.5471  
Epoch 17/20  
278/278 - 5s - loss: 0.0846 - accuracy: 0.9789  
Epoch 17/20  
278/278 - 5s - loss: 0.4468 - accuracy: 0.7865  
Epoch 17/20  
278/278 - 5s - loss: 0.4324 - accuracy: 0.7852  
Epoch 17/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 17/20  
278/278 - 5s - loss: 0.4659 - accuracy: 0.7791  
Epoch 17/20  
278/278 - 6s - loss: 0.4521 - accuracy: 0.7787  
Epoch 17/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 17/20  
278/278 - 5s - loss: 0.5165 - accuracy: 0.7712  
Epoch 17/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 18/20  
278/278 - 5s - loss: 6.9708 - accuracy: 0.5474  
Epoch 18/20  
278/278 - 5s - loss: 0.0836 - accuracy: 0.9790  
Epoch 18/20  
278/278 - 5s - loss: 0.4432 - accuracy: 0.7874  
Epoch 18/20  
278/278 - 5s - loss: 0.4318 - accuracy: 0.7886  
Epoch 18/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 18/20  
278/278 - 5s - loss: 0.4485 - accuracy: 0.7782  
Epoch 18/20  
278/278 - 6s - loss: 0.4599 - accuracy: 0.7782  
Epoch 18/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 18/20  
278/278 - 6s - loss: 0.5138 - accuracy: 0.7741  
Epoch 19/20  
278/278 - 5s - loss: 6.9689 - accuracy: 0.5475  
Epoch 18/20  
278/278 - 6s - loss: 8.0444 - accuracy: 0.4785  
Epoch 19/20  
278/278 - 5s - loss: 0.0834 - accuracy: 0.9788  
Epoch 19/20  
278/278 - 5s - loss: 0.4421 - accuracy: 0.7844  
Epoch 19/20

```

278/278 - 5s - loss: 0.4323 - accuracy: 0.7857
Epoch 19/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 19/20
278/278 - 5s - loss: 0.4472 - accuracy: 0.7761
Epoch 19/20
278/278 - 5s - loss: 0.4555 - accuracy: 0.7802
Epoch 19/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 19/20
278/278 - 5s - loss: 0.5115 - accuracy: 0.7746
Epoch 20/20
278/278 - 5s - loss: 6.9575 - accuracy: 0.5480

2022-03-05 14:02:24.053346: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 19/20
278/278 - 5s - loss: 8.0444 - accuracy: 0.4785
Epoch 20/20
278/278 - 5s - loss: 0.0828 - accuracy: 0.9787
Epoch 20/20
278/278 - 5s - loss: 0.4400 - accuracy: 0.7875

2022-03-05 14:02:24.987554: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:02:25.029082: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 20/20
278/278 - 5s - loss: 0.4320 - accuracy: 0.7873

2022-03-05 14:02:25.240497: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

139/139 - 2s - loss: 0.2337 - accuracy: 0.9847
Epoch 20/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785

2022-03-05 14:02:26.247110: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

139/139 - 2s - loss: 2.8670 - accuracy: 0.0399
Epoch 20/20
278/278 - 5s - loss: 0.4475 - accuracy: 0.7746
139/139 - 2s - loss: 0.4256 - accuracy: 0.8139

```

```

2022-03-05 14:02:26.731374: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:02:26.801495: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

139/139 - 2s - loss: 0.3577 - accuracy: 0.8779
Epoch 20/20
278/278 - 5s - loss: 0.4546 - accuracy: 0.7799

2022-03-05 14:02:27.000906: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 20/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785

2022-03-05 14:02:27.294942: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:02:27.396531: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 20/20
278/278 - 4s - loss: 0.5127 - accuracy: 0.7701
139/139 - 1s - loss: 15.4215 - accuracy: 2.2533e-04

2022-03-05 14:02:27.549208: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

139/139 - 1s - loss: 0.5194 - accuracy: 0.8319
139/139 - 1s - loss: 0.4211 - accuracy: 0.7954
Epoch 20/20
278/278 - 4s - loss: 8.0444 - accuracy: 0.4785
139/139 - 1s - loss: 15.4220 - accuracy: 0.0000e+00

2022-03-05 14:02:28.314245: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

139/139 - 1s - loss: 0.5157 - accuracy: 0.8328
139/139 - 1s - loss: 0.0000e+00 - accuracy: 1.0000
Epoch 1/20
278/278 - 3s - loss: 7.1782 - accuracy: 0.5311
Epoch 1/20
278/278 - 3s - loss: 14.9194 - accuracy: 0.0216
Epoch 2/20
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000
Epoch 2/20

```

278/278 - 1s - loss: 14.9194 - accuracy: 0.0216  
Epoch 3/20  
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000  
Epoch 3/20  
278/278 - 1s - loss: 14.9194 - accuracy: 0.0216  
Epoch 4/20  
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000  
Epoch 4/20  
278/278 - 1s - loss: 14.9194 - accuracy: 0.0216  
Epoch 5/20  
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000  
Epoch 5/20  
278/278 - 1s - loss: 14.9194 - accuracy: 0.0216  
Epoch 6/20  
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000  
Epoch 6/20  
278/278 - 1s - loss: 14.9194 - accuracy: 0.0216  
Epoch 7/20  
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000  
Epoch 7/20  
278/278 - 1s - loss: 14.9194 - accuracy: 0.0216  
Epoch 8/20  
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000  
Epoch 8/20  
278/278 - 1s - loss: 14.9194 - accuracy: 0.0216  
Epoch 9/20  
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000  
Epoch 9/20  
278/278 - 1s - loss: 14.9194 - accuracy: 0.0216  
Epoch 10/20  
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000  
Epoch 10/20  
278/278 - 1s - loss: 14.9194 - accuracy: 0.0216  
Epoch 11/20  
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000  
Epoch 11/20  
278/278 - 1s - loss: 14.9194 - accuracy: 0.0216  
Epoch 12/20  
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000  
Epoch 12/20  
278/278 - 1s - loss: 14.9194 - accuracy: 0.0216  
Epoch 13/20  
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000  
Epoch 13/20  
278/278 - 1s - loss: 14.9194 - accuracy: 0.0216  
Epoch 14/20  
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000  
Epoch 14/20

```

278/278 - 1s - loss: 14.9194 - accuracy: 0.0216
Epoch 15/20
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000
Epoch 15/20
278/278 - 1s - loss: 14.9194 - accuracy: 0.0216
Epoch 16/20
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000
Epoch 16/20
278/278 - 1s - loss: 14.9194 - accuracy: 0.0216
Epoch 17/20
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000
Epoch 17/20
278/278 - 1s - loss: 14.9194 - accuracy: 0.0216
Epoch 18/20
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000
Epoch 18/20
278/278 - 1s - loss: 14.9194 - accuracy: 0.0216
Epoch 19/20
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000
Epoch 19/20
278/278 - 1s - loss: 14.9194 - accuracy: 0.0216
Epoch 20/20
278/278 - 1s - loss: 7.6246 - accuracy: 0.5000
Epoch 20/20
278/278 - 1s - loss: 14.9194 - accuracy: 0.0216

2022-03-05 14:02:55.277396: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:02:55.473316: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

139/139 - 0s - loss: 14.5930 - accuracy: 0.0430
139/139 - 0s - loss: 0.0000e+00 - accuracy: 1.0000
Epoch 1/20

2022-03-05 14:02:56.226869: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

417/417 - 2s - loss: 4.7388 - accuracy: 0.6915
Epoch 2/20
417/417 - 2s - loss: 5.0438 - accuracy: 0.6686
Epoch 3/20
417/417 - 2s - loss: 4.6240 - accuracy: 0.6972
Epoch 4/20
417/417 - 2s - loss: 4.7068 - accuracy: 0.6934
Epoch 5/20
417/417 - 2s - loss: 5.1382 - accuracy: 0.6668

```

```

Epoch 6/20
417/417 - 2s - loss: 4.9293 - accuracy: 0.6784
Epoch 7/20
417/417 - 2s - loss: 4.7887 - accuracy: 0.6877
Epoch 8/20
417/417 - 2s - loss: 4.6728 - accuracy: 0.6966
Epoch 9/20
417/417 - 2s - loss: 4.5858 - accuracy: 0.7014
Epoch 10/20
417/417 - 2s - loss: 4.5059 - accuracy: 0.7068
Epoch 11/20
417/417 - 2s - loss: 4.4779 - accuracy: 0.7076
Epoch 12/20
417/417 - 2s - loss: 4.4735 - accuracy: 0.7089
Epoch 13/20
417/417 - 2s - loss: 4.9149 - accuracy: 0.6779
Epoch 14/20
417/417 - 2s - loss: 4.6781 - accuracy: 0.6959
Epoch 15/20
417/417 - 2s - loss: 4.5182 - accuracy: 0.7050
Epoch 16/20
417/417 - 2s - loss: 5.0702 - accuracy: 0.6709
Epoch 17/20
417/417 - 2s - loss: 5.0651 - accuracy: 0.6714
Epoch 18/20
417/417 - 2s - loss: 5.0557 - accuracy: 0.6720
Epoch 19/20
417/417 - 2s - loss: 5.0163 - accuracy: 0.6747
Epoch 20/20
417/417 - 2s - loss: 4.9876 - accuracy: 0.6763

```

```

[36]: # summarize results
print("Best: %f using %s" % (grid_result.best_score_, grid_result.best_params_))
means = grid_result.cv_results_['mean_test_score']
stds = grid_result.cv_results_['std_test_score']
params = grid_result.cv_results_['params']
for mean, stdev, param in zip(means, stds, params):
    print("%f (%f) with: %r" % (mean, stdev, param))

```

```

Best: 0.675905 using {'activation': 'linear'}
0.610936 (0.437356) with: {'activation': 'relu'}
0.542512 (0.383744) with: {'activation': 'tanh'}
0.577212 (0.380846) with: {'activation': 'sigmoid'}
0.675905 (0.447549) with: {'activation': 'linear'}

```

## 2b) Tune the Number of Neurons in the Hidden Layer

```
[37]: # define the grid search parameters
neurons = [5, 10, 15]
param_grid = dict(neurons=neurons)
grid = GridSearchCV(estimator=model, param_grid=param_grid, n_jobs=-1, cv=3)
grid_result = grid.fit(X_train, y_train)
```

```
2022-03-05 14:03:32.019001: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:03:32.037342: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:03:32.037832: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:03:32.047052: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:03:32.048814: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:03:32.061919: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:03:32.066555: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:03:32.071750: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:03:32.089949: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 1/20
278/278 - 5s - loss: 0.9573 - accuracy: 0.9318
Epoch 1/20
278/278 - 5s - loss: 0.3497 - accuracy: 0.9771
Epoch 1/20
278/278 - 5s - loss: 7.8085 - accuracy: 0.4659
Epoch 1/20
278/278 - 5s - loss: 0.3290 - accuracy: 0.9786
Epoch 1/20
278/278 - 5s - loss: 2.7988 - accuracy: 0.6336
Epoch 1/20
278/278 - 5s - loss: 5.1611 - accuracy: 0.6336
Epoch 1/20
278/278 - 5s - loss: 7.0762 - accuracy: 0.5246
```

Epoch 1/20  
278/278 - 6s - loss: 7.2987 - accuracy: 0.5211  
Epoch 1/20  
278/278 - 6s - loss: 7.6264 - accuracy: 0.4998  
Epoch 2/20  
278/278 - 5s - loss: 7.3403 - accuracy: 0.4743  
Epoch 2/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 2/20  
278/278 - 5s - loss: 0.3336 - accuracy: 0.9784  
Epoch 2/20  
278/278 - 5s - loss: 5.5783 - accuracy: 0.6187  
Epoch 2/20  
278/278 - 5s - loss: 1.8410 - accuracy: 0.6721  
Epoch 2/20  
278/278 - 5s - loss: 0.3285 - accuracy: 0.9787  
Epoch 2/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 2/20  
278/278 - 5s - loss: 3.8448 - accuracy: 0.7248  
Epoch 2/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 3/20  
278/278 - 5s - loss: 6.4016 - accuracy: 0.5367  
Epoch 3/20  
278/278 - 5s - loss: 0.3336 - accuracy: 0.9784  
Epoch 3/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 3/20  
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
Epoch 3/20  
278/278 - 5s - loss: 5.4890 - accuracy: 0.6256  
Epoch 3/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 3/20  
278/278 - 5s - loss: 2.8203 - accuracy: 0.5878  
Epoch 3/20  
278/278 - 5s - loss: 4.1016 - accuracy: 0.7066  
Epoch 3/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 4/20  
278/278 - 5s - loss: 7.3795 - accuracy: 0.4923  
Epoch 4/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 4/20  
278/278 - 5s - loss: 0.3336 - accuracy: 0.9784  
Epoch 4/20  
278/278 - 5s - loss: 4.9859 - accuracy: 0.6559



Epoch 4/20  
 278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
 Epoch 4/20  
 278/278 - 5s - loss: 4.7682 - accuracy: 0.6727  
 Epoch 4/20  
 278/278 - 5s - loss: 1.1150 - accuracy: 0.6192  
 Epoch 4/20  
 278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
 Epoch 4/20  
 278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
 Epoch 5/20  
 278/278 - 5s - loss: 5.4771 - accuracy: 0.6098  
 Epoch 5/20  
 278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 5/20  
 278/278 - 5s - loss: 0.3336 - accuracy: 0.9784  
 Epoch 5/20  
 278/278 - 5s - loss: 5.0897 - accuracy: 0.6528  
 Epoch 5/20  
 278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
 Epoch 5/20  
 278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
 Epoch 5/20  
 278/278 - 5s - loss: 1.2841 - accuracy: 0.6238  
 Epoch 5/20  
 278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
 Epoch 5/20  
 278/278 - 5s - loss: 6.4780 - accuracy: 0.5703  
 Epoch 6/20  
 278/278 - 5s - loss: 4.4485 - accuracy: 0.6716  
 Epoch 6/20  
 278/278 - 5s - loss: 0.3336 - accuracy: 0.9784  
 Epoch 6/20  
 278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 6/20  
 278/278 - 5s - loss: 4.2253 - accuracy: 0.7041  
 Epoch 6/20  
 278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
 Epoch 6/20  
 278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
 Epoch 6/20  
 278/278 - 5s - loss: 0.9021 - accuracy: 0.6488  
 Epoch 6/20  
 278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
 Epoch 6/20  
 278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
 Epoch 7/20  
 278/278 - 5s - loss: 5.2631 - accuracy: 0.6251

Epoch 7/20  
 278/278 - 5s - loss: 0.3336 - accuracy: 0.9784  
 Epoch 7/20  
 278/278 - 5s - loss: 4.7681 - accuracy: 0.6753  
 Epoch 7/20  
 278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 7/20  
 278/278 - 5s - loss: 0.6925 - accuracy: 0.6943  
 Epoch 7/20  
 278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
 Epoch 7/20  
 278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
 Epoch 7/20  
 278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
 Epoch 7/20  
 278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
 Epoch 8/20  
 278/278 - 5s - loss: 4.0921 - accuracy: 0.7167  
 Epoch 8/20  
 278/278 - 5s - loss: 5.6544 - accuracy: 0.6104  
 Epoch 8/20  
 278/278 - 5s - loss: 0.3336 - accuracy: 0.9784  
 Epoch 8/20  
 278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 8/20  
 278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
 Epoch 8/20  
 278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
 Epoch 8/20  
 278/278 - 5s - loss: 0.7117 - accuracy: 0.7093  
 Epoch 8/20  
 278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
 Epoch 8/20  
 278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
 Epoch 9/20  
 278/278 - 5s - loss: 7.1973 - accuracy: 0.5281  
 Epoch 9/20  
 278/278 - 5s - loss: 7.6141 - accuracy: 0.5000  
 Epoch 9/20  
 278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
 Epoch 9/20  
 278/278 - 5s - loss: 0.3336 - accuracy: 0.9784  
 Epoch 9/20  
 278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
 Epoch 9/20  
 278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
 Epoch 9/20  
 278/278 - 5s - loss: 0.6441 - accuracy: 0.7321

Epoch 9/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 9/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 10/20  
278/278 - 5s - loss: 6.7412 - accuracy: 0.5561  
Epoch 10/20  
278/278 - 5s - loss: 7.6247 - accuracy: 0.4999  
Epoch 10/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 10/20  
278/278 - 5s - loss: 0.3336 - accuracy: 0.9784  
Epoch 10/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 10/20  
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
Epoch 10/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 10/20  
278/278 - 5s - loss: 0.6065 - accuracy: 0.7405  
Epoch 10/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 11/20  
278/278 - 5s - loss: 6.0551 - accuracy: 0.5986  
Epoch 11/20  
278/278 - 5s - loss: 7.6247 - accuracy: 0.5000  
Epoch 11/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 11/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 11/20  
278/278 - 5s - loss: 0.3336 - accuracy: 0.9784  
Epoch 11/20  
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
Epoch 11/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 11/20  
278/278 - 5s - loss: 0.6263 - accuracy: 0.7423  
Epoch 11/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 12/20  
278/278 - 5s - loss: 4.5733 - accuracy: 0.6809  
Epoch 12/20  
278/278 - 5s - loss: 7.6247 - accuracy: 0.5000  
Epoch 12/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 12/20  
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786

Epoch 12/20  
278/278 - 5s - loss: 0.3336 - accuracy: 0.9784  
Epoch 12/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 12/20  
278/278 - 5s - loss: 0.6049 - accuracy: 0.7252  
Epoch 12/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 12/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 13/20  
278/278 - 5s - loss: 4.1458 - accuracy: 0.7085  
Epoch 13/20  
278/278 - 5s - loss: 7.6247 - accuracy: 0.5000  
Epoch 13/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 13/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 13/20  
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
Epoch 13/20  
278/278 - 5s - loss: 0.3336 - accuracy: 0.9784  
Epoch 13/20  
278/278 - 5s - loss: 0.5745 - accuracy: 0.7520  
Epoch 13/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 13/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 14/20  
278/278 - 5s - loss: 4.1014 - accuracy: 0.7098  
Epoch 14/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 14/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 14/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 14/20  
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
Epoch 14/20  
278/278 - 5s - loss: 0.3336 - accuracy: 0.9784  
Epoch 14/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 14/20  
278/278 - 5s - loss: 0.6856 - accuracy: 0.7458  
Epoch 14/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 15/20  
278/278 - 5s - loss: 3.9854 - accuracy: 0.7194

Epoch 15/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 15/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 15/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 15/20  
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
Epoch 15/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 15/20  
278/278 - 5s - loss: 0.3336 - accuracy: 0.9784  
Epoch 15/20  
278/278 - 5s - loss: 0.5578 - accuracy: 0.7547  
Epoch 15/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 16/20  
278/278 - 5s - loss: 3.4693 - accuracy: 0.6840  
Epoch 16/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 16/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 16/20  
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
Epoch 16/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 16/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 16/20  
278/278 - 5s - loss: 0.3336 - accuracy: 0.9784  
Epoch 16/20  
278/278 - 5s - loss: 0.5508 - accuracy: 0.7678  
Epoch 16/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 17/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215  
Epoch 17/20  
278/278 - 5s - loss: 2.3735 - accuracy: 0.6530  
Epoch 17/20  
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000  
Epoch 17/20  
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786  
Epoch 17/20  
278/278 - 5s - loss: 0.3336 - accuracy: 0.9784  
Epoch 17/20  
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785  
Epoch 17/20  
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215

```

Epoch 17/20
278/278 - 5s - loss: 0.5464 - accuracy: 0.7588
Epoch 17/20
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000
Epoch 18/20
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215
Epoch 18/20
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000
Epoch 18/20
278/278 - 5s - loss: 2.6699 - accuracy: 0.6248
Epoch 18/20
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786
Epoch 18/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 18/20
278/278 - 5s - loss: 0.5679 - accuracy: 0.7634
Epoch 18/20
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215
Epoch 18/20
278/278 - 5s - loss: 0.3336 - accuracy: 0.9784
Epoch 18/20
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000
Epoch 19/20
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000
Epoch 19/20
278/278 - 5s - loss: 6.1009 - accuracy: 0.5081
Epoch 19/20
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215
Epoch 19/20
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786
Epoch 19/20
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215
Epoch 19/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785
Epoch 19/20
278/278 - 5s - loss: 0.3336 - accuracy: 0.9784
Epoch 19/20
278/278 - 5s - loss: 0.6500 - accuracy: 0.7507
Epoch 19/20
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000
Epoch 20/20
278/278 - 5s - loss: 1.0698 - accuracy: 0.6518
Epoch 20/20
278/278 - 5s - loss: 7.6246 - accuracy: 0.5000

2022-03-05 14:05:09.696390: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

```

```

2022-03-05 14:05:09.898150: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:05:10.086003: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 20/20
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215
Epoch 20/20
278/278 - 5s - loss: 0.3302 - accuracy: 0.9786

2022-03-05 14:05:10.394628: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 20/20
278/278 - 4s - loss: 0.6050 - accuracy: 0.7474
Epoch 20/20
278/278 - 5s - loss: 7.2965 - accuracy: 0.5215
Epoch 20/20
278/278 - 5s - loss: 0.3336 - accuracy: 0.9784
Epoch 20/20
278/278 - 5s - loss: 0.3319 - accuracy: 0.9785

2022-03-05 14:05:10.740465: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:05:10.805240: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.
2022-03-05 14:05:10.805623: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

Epoch 20/20
278/278 - 4s - loss: 7.6246 - accuracy: 0.5000
139/139 - 1s - loss: 0.5022 - accuracy: 0.8179

2022-03-05 14:05:10.978121: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

139/139 - 1s - loss: 14.5930 - accuracy: 0.0430
139/139 - 1s - loss: 15.2493 - accuracy: 0.0000e+00
139/139 - 1s - loss: 15.4020 - accuracy: 4.5065e-04
139/139 - 1s - loss: 15.2493 - accuracy: 0.0000e+00
139/139 - 1s - loss: 15.3359 - accuracy: 0.0056
139/139 - 1s - loss: 15.4249 - accuracy: 0.0000e+00
139/139 - 1s - loss: 14.5930 - accuracy: 0.0430

```

2022-03-05 14:05:54.153313: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.

139/139 - 0s - loss: 0.6548 - accuracy: 0.8010  
Epoch 1/20

2022-03-05 14:05:54.941858: I  
tensorflow/core/grappler/optimizers/custom\_graph\_optimizer\_registry.cc:112]  
Plugin optimizer for device\_type GPU is enabled.

417/417 - 2s - loss: 5.1792 - accuracy: 0.5952  
Epoch 2/20

417/417 - 2s - loss: 4.0599 - accuracy: 0.7011  
Epoch 3/20

417/417 - 2s - loss: 4.3298 - accuracy: 0.7080  
Epoch 4/20

417/417 - 2s - loss: 5.0775 - accuracy: 0.6679  
Epoch 5/20

417/417 - 2s - loss: 4.8664 - accuracy: 0.6793  
Epoch 6/20

417/417 - 2s - loss: 3.9346 - accuracy: 0.7215  
Epoch 7/20

417/417 - 2s - loss: 4.4149 - accuracy: 0.6915  
Epoch 8/20

417/417 - 2s - loss: 5.1724 - accuracy: 0.6625  
Epoch 9/20

417/417 - 2s - loss: 7.6783 - accuracy: 0.4869  
Epoch 10/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477  
Epoch 11/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477  
Epoch 12/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477  
Epoch 13/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477  
Epoch 14/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477  
Epoch 15/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477  
Epoch 16/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477  
Epoch 17/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477  
Epoch 18/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477  
Epoch 19/20

417/417 - 2s - loss: 9.9474 - accuracy: 0.3477  
Epoch 20/20



417/417 - 2s - loss: 9.9474 - accuracy: 0.3477

```
[38]: # summarize results
print("Best: %f using %s" % (grid_result.best_score_, grid_result.best_params_))
means = grid_result.cv_results_['mean_test_score']
stds = grid_result.cv_results_['std_test_score']
params = grid_result.cv_results_['params']
for mean, stdev, param in zip(means, stds, params):
    print("%f (%f) with: %r" % (mean, stdev, param))
```

```
Best: 0.281358 using {'neurons': 10}
0.272796 (0.385473) with: {'neurons': 5}
0.281358 (0.367888) with: {'neurons': 10}
0.016224 (0.019099) with: {'neurons': 15}
```

```
[39]: # Print weights

for layer_depth, layer in enumerate(a.layers):
    weights = layer.get_weights()[0]
    biases = layer.get_weights()[1]
    print('----- Layer', layer_depth, '-----')
    for toNeuronNum, bias in enumerate(biases):
        print(f'Bias to Layer{layer_depth+1}Neuron{toNeuronNum}: {bias}')

    for fromNeuronNum, wgt in enumerate(weights):
        for toNeuronNum, wgt2 in enumerate(wgt):
            print(f'Layer{layer_depth}, Neuron{fromNeuronNum} to_
↳ Layer{layer_depth+1}, Neuron{toNeuronNum} = {wgt2}')
```

```
----- Layer 0 -----
Bias to Layer1Neuron0: 0.0
Bias to Layer1Neuron1: 0.0
Bias to Layer1Neuron2: 0.0
Bias to Layer1Neuron3: 0.0
Bias to Layer1Neuron4: 0.0
Bias to Layer1Neuron5: 0.0
Bias to Layer1Neuron6: 0.0
Bias to Layer1Neuron7: 0.0
Bias to Layer1Neuron8: 0.0
Bias to Layer1Neuron9: 0.0
Bias to Layer1Neuron10: 0.0
Layer0, Neuron0 to Layer1, Neuron0 = 0.00471264636144042
Layer0, Neuron0 to Layer1, Neuron1 = -0.039118509739637375
Layer0, Neuron0 to Layer1, Neuron2 = -0.05214536190032959
Layer0, Neuron0 to Layer1, Neuron3 = -0.006592115852981806
Layer0, Neuron0 to Layer1, Neuron4 = 0.03783551976084709
Layer0, Neuron0 to Layer1, Neuron5 = -0.06769146025180817
```

Layer0, Neuron0 to Layer1, Neuron6 = 0.03513351455330849  
 Layer0, Neuron0 to Layer1, Neuron7 = 0.06612303107976913  
 Layer0, Neuron0 to Layer1, Neuron8 = 0.00776019087061286  
 Layer0, Neuron0 to Layer1, Neuron9 = -0.054880280047655106  
 Layer0, Neuron0 to Layer1, Neuron10 = 0.016329146921634674  
 Layer0, Neuron1 to Layer1, Neuron0 = -0.08323292434215546  
 Layer0, Neuron1 to Layer1, Neuron1 = -0.05143308266997337  
 Layer0, Neuron1 to Layer1, Neuron2 = 0.025404799729585648  
 Layer0, Neuron1 to Layer1, Neuron3 = -0.030183428898453712  
 Layer0, Neuron1 to Layer1, Neuron4 = 0.07153724879026413  
 Layer0, Neuron1 to Layer1, Neuron5 = 0.01769333705306053  
 Layer0, Neuron1 to Layer1, Neuron6 = 0.03796250373125076  
 Layer0, Neuron1 to Layer1, Neuron7 = -0.04299270734190941  
 Layer0, Neuron1 to Layer1, Neuron8 = -0.03150014206767082  
 Layer0, Neuron1 to Layer1, Neuron9 = -0.09337855875492096  
 Layer0, Neuron1 to Layer1, Neuron10 = -0.17001621425151825  
 Layer0, Neuron2 to Layer1, Neuron0 = 0.006621252745389938  
 Layer0, Neuron2 to Layer1, Neuron1 = -0.05493677780032158  
 Layer0, Neuron2 to Layer1, Neuron2 = -0.008955532684922218  
 Layer0, Neuron2 to Layer1, Neuron3 = 0.09369393438100815  
 Layer0, Neuron2 to Layer1, Neuron4 = -0.06146968528628349  
 Layer0, Neuron2 to Layer1, Neuron5 = 0.10174353420734406  
 Layer0, Neuron2 to Layer1, Neuron6 = 0.016957391053438187  
 Layer0, Neuron2 to Layer1, Neuron7 = -0.003789742710068822  
 Layer0, Neuron2 to Layer1, Neuron8 = -0.00865277461707592  
 Layer0, Neuron2 to Layer1, Neuron9 = 0.033199209719896317  
 Layer0, Neuron2 to Layer1, Neuron10 = 0.05139966681599617  
 Layer0, Neuron3 to Layer1, Neuron0 = 0.0907844677567482  
 Layer0, Neuron3 to Layer1, Neuron1 = 0.009471600875258446  
 Layer0, Neuron3 to Layer1, Neuron2 = 0.016817884519696236  
 Layer0, Neuron3 to Layer1, Neuron3 = -0.03338630869984627  
 Layer0, Neuron3 to Layer1, Neuron4 = -0.002547498792409897  
 Layer0, Neuron3 to Layer1, Neuron5 = -0.04192865267395973  
 Layer0, Neuron3 to Layer1, Neuron6 = -0.04080595448613167  
 Layer0, Neuron3 to Layer1, Neuron7 = -0.053773511201143265  
 Layer0, Neuron3 to Layer1, Neuron8 = 0.018576188012957573  
 Layer0, Neuron3 to Layer1, Neuron9 = -0.10552225261926651  
 Layer0, Neuron3 to Layer1, Neuron10 = 0.054268162697553635  
 Layer0, Neuron4 to Layer1, Neuron0 = 0.014581725001335144  
 Layer0, Neuron4 to Layer1, Neuron1 = 0.03232618793845177  
 Layer0, Neuron4 to Layer1, Neuron2 = -0.01911327615380287  
 Layer0, Neuron4 to Layer1, Neuron3 = 0.011890311725437641  
 Layer0, Neuron4 to Layer1, Neuron4 = -0.062274254858493805  
 Layer0, Neuron4 to Layer1, Neuron5 = 0.0020528242457658052  
 Layer0, Neuron4 to Layer1, Neuron6 = 0.11293806880712509  
 Layer0, Neuron4 to Layer1, Neuron7 = -0.009806777350604534  
 Layer0, Neuron4 to Layer1, Neuron8 = 0.05515175685286522  
 Layer0, Neuron4 to Layer1, Neuron9 = -0.040380895137786865

Layer0, Neuron4 to Layer1, Neuron10 = -0.018124684691429138  
 Layer0, Neuron5 to Layer1, Neuron0 = 0.006276272237300873  
 Layer0, Neuron5 to Layer1, Neuron1 = -0.04703209921717644  
 Layer0, Neuron5 to Layer1, Neuron2 = -0.014488585293293  
 Layer0, Neuron5 to Layer1, Neuron3 = -0.0012050539953634143  
 Layer0, Neuron5 to Layer1, Neuron4 = 0.035975705832242966  
 Layer0, Neuron5 to Layer1, Neuron5 = 0.06120210513472557  
 Layer0, Neuron5 to Layer1, Neuron6 = -0.06336649507284164  
 Layer0, Neuron5 to Layer1, Neuron7 = -0.04927236959338188  
 Layer0, Neuron5 to Layer1, Neuron8 = -0.0009767161682248116  
 Layer0, Neuron5 to Layer1, Neuron9 = -0.0035931896418333054  
 Layer0, Neuron5 to Layer1, Neuron10 = -0.009588910266757011  
 Layer0, Neuron6 to Layer1, Neuron0 = 0.12753476202487946  
 Layer0, Neuron6 to Layer1, Neuron1 = -0.04268960654735565  
 Layer0, Neuron6 to Layer1, Neuron2 = 0.06141463667154312  
 Layer0, Neuron6 to Layer1, Neuron3 = 0.01943972334265709  
 Layer0, Neuron6 to Layer1, Neuron4 = -0.020243387669324875  
 Layer0, Neuron6 to Layer1, Neuron5 = 0.009479195810854435  
 Layer0, Neuron6 to Layer1, Neuron6 = -0.11212822049856186  
 Layer0, Neuron6 to Layer1, Neuron7 = -0.1425272673368454  
 Layer0, Neuron6 to Layer1, Neuron8 = 0.042990926653146744  
 Layer0, Neuron6 to Layer1, Neuron9 = -0.008359543047845364  
 Layer0, Neuron6 to Layer1, Neuron10 = -0.002382290316745639  
 Layer0, Neuron7 to Layer1, Neuron0 = -0.08716259896755219  
 Layer0, Neuron7 to Layer1, Neuron1 = 0.03623366355895996  
 Layer0, Neuron7 to Layer1, Neuron2 = 0.07795950025320053  
 Layer0, Neuron7 to Layer1, Neuron3 = -0.03189697489142418  
 Layer0, Neuron7 to Layer1, Neuron4 = 0.03558250889182091  
 Layer0, Neuron7 to Layer1, Neuron5 = -0.012377017177641392  
 Layer0, Neuron7 to Layer1, Neuron6 = -0.0332193449139595  
 Layer0, Neuron7 to Layer1, Neuron7 = 0.017070738598704338  
 Layer0, Neuron7 to Layer1, Neuron8 = -0.05050499364733696  
 Layer0, Neuron7 to Layer1, Neuron9 = -0.026334716007113457  
 Layer0, Neuron7 to Layer1, Neuron10 = -0.021053394302725792  
 Layer0, Neuron8 to Layer1, Neuron0 = 0.1145385131239891  
 Layer0, Neuron8 to Layer1, Neuron1 = 0.004055140074342489  
 Layer0, Neuron8 to Layer1, Neuron2 = 0.04080687090754509  
 Layer0, Neuron8 to Layer1, Neuron3 = -0.008520054630935192  
 Layer0, Neuron8 to Layer1, Neuron4 = -0.0056593045592308044  
 Layer0, Neuron8 to Layer1, Neuron5 = -0.03114253841340542  
 Layer0, Neuron8 to Layer1, Neuron6 = 0.04085725173354149  
 Layer0, Neuron8 to Layer1, Neuron7 = 0.04953301325440407  
 Layer0, Neuron8 to Layer1, Neuron8 = -0.005400430876761675  
 Layer0, Neuron8 to Layer1, Neuron9 = 0.02225658856332302  
 Layer0, Neuron8 to Layer1, Neuron10 = -0.017691174522042274  
 Layer0, Neuron9 to Layer1, Neuron0 = -0.010145718231797218  
 Layer0, Neuron9 to Layer1, Neuron1 = 0.012131396681070328  
 Layer0, Neuron9 to Layer1, Neuron2 = -0.019888853654265404

Layer0, Neuron9 to Layer1, Neuron3 = -0.04815494641661644  
 Layer0, Neuron9 to Layer1, Neuron4 = -0.02028660476207733  
 Layer0, Neuron9 to Layer1, Neuron5 = 0.015351724810898304  
 Layer0, Neuron9 to Layer1, Neuron6 = 0.004779484122991562  
 Layer0, Neuron9 to Layer1, Neuron7 = 0.05867016315460205  
 Layer0, Neuron9 to Layer1, Neuron8 = 0.05996471270918846  
 Layer0, Neuron9 to Layer1, Neuron9 = -0.010950436815619469  
 Layer0, Neuron9 to Layer1, Neuron10 = 0.051562465727329254  
 ----- Layer 1 -----  
 Bias to Layer2Neuron0: 0.0  
 Bias to Layer2Neuron1: 0.0  
 Bias to Layer2Neuron2: 0.0  
 Bias to Layer2Neuron3: 0.0  
 Bias to Layer2Neuron4: 0.0  
 Bias to Layer2Neuron5: 0.0  
 Bias to Layer2Neuron6: 0.0  
 Bias to Layer2Neuron7: 0.0  
 Bias to Layer2Neuron8: 0.0  
 Bias to Layer2Neuron9: 0.0  
 Bias to Layer2Neuron10: 0.0  
 Layer1, Neuron0 to Layer2, Neuron0 = -0.4208645820617676  
 Layer1, Neuron0 to Layer2, Neuron1 = 0.1373680830001831  
 Layer1, Neuron0 to Layer2, Neuron2 = 0.387209415435791  
 Layer1, Neuron0 to Layer2, Neuron3 = -0.23238056898117065  
 Layer1, Neuron0 to Layer2, Neuron4 = 0.3626587390899658  
 Layer1, Neuron0 to Layer2, Neuron5 = -0.4018961191177368  
 Layer1, Neuron0 to Layer2, Neuron6 = 0.28540676832199097  
 Layer1, Neuron0 to Layer2, Neuron7 = 0.15868467092514038  
 Layer1, Neuron0 to Layer2, Neuron8 = -0.37530040740966797  
 Layer1, Neuron0 to Layer2, Neuron9 = -0.40604156255722046  
 Layer1, Neuron0 to Layer2, Neuron10 = 0.3581898808479309  
 Layer1, Neuron1 to Layer2, Neuron0 = -0.3567938506603241  
 Layer1, Neuron1 to Layer2, Neuron1 = -0.11029931902885437  
 Layer1, Neuron1 to Layer2, Neuron2 = -0.4067521393299103  
 Layer1, Neuron1 to Layer2, Neuron3 = 0.3049352765083313  
 Layer1, Neuron1 to Layer2, Neuron4 = -0.2579157054424286  
 Layer1, Neuron1 to Layer2, Neuron5 = 0.2451302409172058  
 Layer1, Neuron1 to Layer2, Neuron6 = -0.23632416129112244  
 Layer1, Neuron1 to Layer2, Neuron7 = 0.014101147651672363  
 Layer1, Neuron1 to Layer2, Neuron8 = -0.48246344923973083  
 Layer1, Neuron1 to Layer2, Neuron9 = -0.40802001953125  
 Layer1, Neuron1 to Layer2, Neuron10 = -0.19057968258857727  
 Layer1, Neuron2 to Layer2, Neuron0 = 0.11867821216583252  
 Layer1, Neuron2 to Layer2, Neuron1 = 0.24089229106903076  
 Layer1, Neuron2 to Layer2, Neuron2 = 0.3517571687698364  
 Layer1, Neuron2 to Layer2, Neuron3 = -0.41698262095451355  
 Layer1, Neuron2 to Layer2, Neuron4 = 0.3198556900024414  
 Layer1, Neuron2 to Layer2, Neuron5 = -0.46381881833076477

Layer1, Neuron2 to Layer2, Neuron6 = -0.30716341733932495  
 Layer1, Neuron2 to Layer2, Neuron7 = 0.0444219708442688  
 Layer1, Neuron2 to Layer2, Neuron8 = -0.1380370557308197  
 Layer1, Neuron2 to Layer2, Neuron9 = -0.5041273236274719  
 Layer1, Neuron2 to Layer2, Neuron10 = 0.12454777956008911  
 Layer1, Neuron3 to Layer2, Neuron0 = 0.22557705640792847  
 Layer1, Neuron3 to Layer2, Neuron1 = 0.482516348361969  
 Layer1, Neuron3 to Layer2, Neuron2 = 0.5136569142341614  
 Layer1, Neuron3 to Layer2, Neuron3 = -0.3042416572570801  
 Layer1, Neuron3 to Layer2, Neuron4 = -0.013297677040100098  
 Layer1, Neuron3 to Layer2, Neuron5 = 0.09864753484725952  
 Layer1, Neuron3 to Layer2, Neuron6 = -0.34179413318634033  
 Layer1, Neuron3 to Layer2, Neuron7 = -0.4258114993572235  
 Layer1, Neuron3 to Layer2, Neuron8 = -0.006602168083190918  
 Layer1, Neuron3 to Layer2, Neuron9 = -0.08363699913024902  
 Layer1, Neuron3 to Layer2, Neuron10 = -0.07731762528419495  
 Layer1, Neuron4 to Layer2, Neuron0 = -0.3327525854110718  
 Layer1, Neuron4 to Layer2, Neuron1 = -0.04065936803817749  
 Layer1, Neuron4 to Layer2, Neuron2 = -0.2138402760028839  
 Layer1, Neuron4 to Layer2, Neuron3 = -0.34509390592575073  
 Layer1, Neuron4 to Layer2, Neuron4 = 0.5080649256706238  
 Layer1, Neuron4 to Layer2, Neuron5 = -0.41418975591659546  
 Layer1, Neuron4 to Layer2, Neuron6 = -0.05631762742996216  
 Layer1, Neuron4 to Layer2, Neuron7 = -0.28665298223495483  
 Layer1, Neuron4 to Layer2, Neuron8 = 0.45268362760543823  
 Layer1, Neuron4 to Layer2, Neuron9 = -0.07652649283409119  
 Layer1, Neuron4 to Layer2, Neuron10 = -0.06976696848869324  
 Layer1, Neuron5 to Layer2, Neuron0 = 0.2487180233001709  
 Layer1, Neuron5 to Layer2, Neuron1 = -0.33621856570243835  
 Layer1, Neuron5 to Layer2, Neuron2 = 0.03507322072982788  
 Layer1, Neuron5 to Layer2, Neuron3 = -0.17217236757278442  
 Layer1, Neuron5 to Layer2, Neuron4 = 0.38439881801605225  
 Layer1, Neuron5 to Layer2, Neuron5 = 0.2426844835281372  
 Layer1, Neuron5 to Layer2, Neuron6 = 0.3786622881889343  
 Layer1, Neuron5 to Layer2, Neuron7 = 0.3617924451828003  
 Layer1, Neuron5 to Layer2, Neuron8 = -0.15387773513793945  
 Layer1, Neuron5 to Layer2, Neuron9 = -0.4450729489326477  
 Layer1, Neuron5 to Layer2, Neuron10 = -0.29081547260284424  
 Layer1, Neuron6 to Layer2, Neuron0 = -0.448844850063324  
 Layer1, Neuron6 to Layer2, Neuron1 = -0.1164804995059967  
 Layer1, Neuron6 to Layer2, Neuron2 = 0.5188536047935486  
 Layer1, Neuron6 to Layer2, Neuron3 = 0.20154500007629395  
 Layer1, Neuron6 to Layer2, Neuron4 = 0.12524563074111938  
 Layer1, Neuron6 to Layer2, Neuron5 = -0.11703184247016907  
 Layer1, Neuron6 to Layer2, Neuron6 = -0.2877503037452698  
 Layer1, Neuron6 to Layer2, Neuron7 = -0.3047405481338501  
 Layer1, Neuron6 to Layer2, Neuron8 = -0.28879567980766296  
 Layer1, Neuron6 to Layer2, Neuron9 = -0.5003443360328674

Layer1, Neuron6 to Layer2, Neuron10 = 0.4624865651130676  
 Layer1, Neuron7 to Layer2, Neuron0 = -0.3516954183578491  
 Layer1, Neuron7 to Layer2, Neuron1 = -0.1712224781513214  
 Layer1, Neuron7 to Layer2, Neuron2 = -0.521925151348114  
 Layer1, Neuron7 to Layer2, Neuron3 = -0.22272193431854248  
 Layer1, Neuron7 to Layer2, Neuron4 = 0.32967519760131836  
 Layer1, Neuron7 to Layer2, Neuron5 = 0.3704230785369873  
 Layer1, Neuron7 to Layer2, Neuron6 = 0.06661301851272583  
 Layer1, Neuron7 to Layer2, Neuron7 = -0.2938069701194763  
 Layer1, Neuron7 to Layer2, Neuron8 = -0.13694274425506592  
 Layer1, Neuron7 to Layer2, Neuron9 = -0.2998095750808716  
 Layer1, Neuron7 to Layer2, Neuron10 = -0.3591799736022949  
 Layer1, Neuron8 to Layer2, Neuron0 = 0.1098182201385498  
 Layer1, Neuron8 to Layer2, Neuron1 = -0.43321287631988525  
 Layer1, Neuron8 to Layer2, Neuron2 = 0.49351245164871216  
 Layer1, Neuron8 to Layer2, Neuron3 = 0.1302652359008789  
 Layer1, Neuron8 to Layer2, Neuron4 = 0.13127344846725464  
 Layer1, Neuron8 to Layer2, Neuron5 = -0.10748890042304993  
 Layer1, Neuron8 to Layer2, Neuron6 = 0.17202341556549072  
 Layer1, Neuron8 to Layer2, Neuron7 = -0.26911985874176025  
 Layer1, Neuron8 to Layer2, Neuron8 = -0.2906917333602905  
 Layer1, Neuron8 to Layer2, Neuron9 = 0.5160512328147888  
 Layer1, Neuron8 to Layer2, Neuron10 = -0.4419912099838257  
 Layer1, Neuron9 to Layer2, Neuron0 = 0.28016579151153564  
 Layer1, Neuron9 to Layer2, Neuron1 = -0.08778044581413269  
 Layer1, Neuron9 to Layer2, Neuron2 = -0.19101482629776  
 Layer1, Neuron9 to Layer2, Neuron3 = 0.4834142327308655  
 Layer1, Neuron9 to Layer2, Neuron4 = 0.4204713702201843  
 Layer1, Neuron9 to Layer2, Neuron5 = 0.4577323794364929  
 Layer1, Neuron9 to Layer2, Neuron6 = 0.324918270111084  
 Layer1, Neuron9 to Layer2, Neuron7 = -0.4134838879108429  
 Layer1, Neuron9 to Layer2, Neuron8 = 0.5027459263801575  
 Layer1, Neuron9 to Layer2, Neuron9 = -0.04726862907409668  
 Layer1, Neuron9 to Layer2, Neuron10 = -0.12587079405784607  
 Layer1, Neuron10 to Layer2, Neuron0 = -0.03842580318450928  
 Layer1, Neuron10 to Layer2, Neuron1 = 0.09650099277496338  
 Layer1, Neuron10 to Layer2, Neuron2 = 0.23484623432159424  
 Layer1, Neuron10 to Layer2, Neuron3 = 0.3069159984588623  
 Layer1, Neuron10 to Layer2, Neuron4 = 0.15244698524475098  
 Layer1, Neuron10 to Layer2, Neuron5 = 0.17703646421432495  
 Layer1, Neuron10 to Layer2, Neuron6 = -0.10812538862228394  
 Layer1, Neuron10 to Layer2, Neuron7 = -0.12208932638168335  
 Layer1, Neuron10 to Layer2, Neuron8 = -0.24612632393836975  
 Layer1, Neuron10 to Layer2, Neuron9 = 0.08950936794281006  
 Layer1, Neuron10 to Layer2, Neuron10 = -0.038844525814056396  
 ----- Layer 2 -----  
 Bias to Layer3Neuron0: 0.0  
 Layer2, Neuron0 to Layer3, Neuron0 = -0.5698533654212952

```

Layer2, Neuron1 to Layer3, Neuron0 = 0.18599724769592285
Layer2, Neuron2 to Layer3, Neuron0 = 0.5242840647697449
Layer2, Neuron3 to Layer3, Neuron0 = -0.3146447539329529
Layer2, Neuron4 to Layer3, Neuron0 = 0.4910423159599304
Layer2, Neuron5 to Layer3, Neuron0 = -0.5441699028015137
Layer2, Neuron6 to Layer3, Neuron0 = 0.3864426016807556
Layer2, Neuron7 to Layer3, Neuron0 = 0.21486008167266846
Layer2, Neuron8 to Layer3, Neuron0 = -0.5081591606140137
Layer2, Neuron9 to Layer3, Neuron0 = -0.5497828722000122
Layer2, Neuron10 to Layer3, Neuron0 = 0.4849913716316223

```

```

[43]: # Evaluate the keras model
a=ann_model()
_, accuracy = a.evaluate(X_train,y_train)
print('Accuracy: %.2f' % (accuracy*100), '%')

```

```

49/417 [==>...] - ETA: 1s - loss: 0.0286 - accuracy:
0.9981

```

```

2022-03-05 14:07:43.063072: I
tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112]
Plugin optimizer for device_type GPU is enabled.

```

```

417/417 [=====] - 2s 3ms/step - loss: -0.9635 -
accuracy: 0.9274
Accuracy: 65.10 %

```

---