In [23]:
```
# Import necessary libraries.
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
import tensorflow as tf
import keras as keras
from sklearn.preprocessing import StandardScaler, OneHotEncoder, LabelEncoder, C
from sklearn.compose import make_column_transformer
from sklearn.model_selection import train_test_split
from sklearn.pipeline import Pipeline
from sklearn.compose import ColumnTransformer
from ucimlrepo import fetch_ucirepo
from tensorflow.keras.regularizers import l2
import keras_tuner as kt
```

Import the Obesity Dataset

In [ ]:
```
# Importing the dataset and data preview.
obesity_data = pd.read_csv("ObesityDataSet_raw_and_data_sinthetic.csv", delimite

# Print the Table
obesity_data.head(15)
```

Out[ ]:

	Gender	Age	Height	Weight	family_history_with_overweight	FAVC	FCVC	N
0	Female	21.0	1.62	64.0	yes	no	2.0	
1	Female	21.0	1.52	56.0	yes	no	3.0	
2	Male	23.0	1.80	77.0	yes	no	2.0	
3	Male	27.0	1.80	87.0	no	no	3.0	
4	Male	22.0	1.78	89.8	no	no	2.0	
5	Male	29.0	1.62	53.0	no	yes	2.0	
6	Female	23.0	1.50	55.0	yes	yes	3.0	
7	Male	22.0	1.64	53.0	no	no	2.0	
8	Male	24.0	1.78	64.0	yes	yes	3.0	
9	Male	22.0	1.72	68.0	yes	yes	2.0	
10	Male	26.0	1.85	105.0	yes	yes	3.0	
11	Female	21.0	1.72	80.0	yes	yes	2.0	
12	Male	22.0	1.65	56.0	no	no	3.0	
13	Male	41.0	1.80	99.0	no	yes	2.0	
14	Male	23.0	1.77	60.0	yes	yes	3.0	

Check the datatype and convert them into correct datatype

In [3]:
```
# Display the data types of each column in the dataset
print(obesity_data.dtypes)
```

```
Gender                           object
Age                             float64
Height                          float64
Weight                          float64
family_history_with_overweight   object
FAVC                             object
FCVC                            float64
NCP                             float64
CAEC                             object
SMOKE                            object
CH2O                            float64
SCC                              object
FAF                             float64
TUE                             float64
CALC                             object
MTRANS                           object
NObeyesdad                       object
dtype: object
```

In [4]:
```
# Convert FCVC and TUE to integers
X = obesity_data.drop(columns=['NObeyesdad']).copy()
X['FCVC'] = X['FCVC'].astype(int)
X['TUE'] = X['TUE'].astype(int)

# Separate target variable
y = obesity_data['NObeyesdad']

# Check the data types again
print(X.dtypes)
```

```
Gender                           object
Age                             float64
Height                          float64
Weight                          float64
family_history_with_overweight   object
FAVC                             object
FCVC                              int32
NCP                             float64
CAEC                             object
SMOKE                            object
CH2O                            float64
SCC                              object
FAF                             float64
TUE                               int32
CALC                             object
MTRANS                           object
dtype: object
```

Split training, validation, and test dataset

In [5]:
```
# Split the data into 60% training, 20% validation, and 20% test
X_train, X_temp, y_train, y_temp = train_test_split(X, y, test_size=0.4, random_
X_val, X_test, y_val, y_test = train_test_split(X_temp, y_temp, test_size=0.5, r
```

Standardize continuous features and encode categorical features

In [6]:
```
# Convert binary features from "yes"/"no" to 1/0 in the training, validation, an
binary_features = ['family_history_with_overweight', 'FAVC', 'SMOKE', 'SCC']

for feature in binary_features:
    X_train[feature] = X_train[feature].map({'yes': 1, 'no': 0})
    X_val[feature] = X_val[feature].map({'yes': 1, 'no': 0})
    X_test[feature] = X_test[feature].map({'yes': 1, 'no': 0})

# Sample columns based on data type
continuous_features = ['Age', 'Height', 'Weight', 'NCP', 'CH2O', 'FAF']
integer_features_to_encode = ['TUE', 'FCVC']  # Only apply OneHotEncoder to FCVC
categorical_features = ['Gender', 'CAEC', 'CALC', 'MTRANS']

# Define ColumnTransformer with the transformations
preprocessor = ColumnTransformer(
    transformers=[
        ('continuous', StandardScaler(), continuous_features),  # Standardize co
        ('binary', 'passthrough', binary_features),  # Binary features are alrea
        ('integer_encode', OneHotEncoder(sparse_output=False), integer_features_
        ('categorical', OneHotEncoder(sparse_output=False), categorical_features
    ])

# Fit the preprocessor only on the training data
X_train_transformed = preprocessor.fit_transform(X_train)

# Transform the validation and test sets using the preprocessor
X_val_transformed = preprocessor.transform(X_val)
X_test_transformed = preprocessor.transform(X_test)

# Check shapes to confirm transformations
print("Train shape:", X_train_transformed.shape)
print("Validation shape:", X_val_transformed.shape)
print("Test shape:", X_test_transformed.shape)
```

```
Train shape: (1266, 31)
Validation shape: (422, 31)
Test shape: (423, 31)
```

In [7]:
```
# Encode labels as integers
label_encoder = LabelEncoder()
y_train = label_encoder.fit_transform(y_train)
y_val = label_encoder.transform(y_val)
y_test = label_encoder.transform(y_test)
```

Set up the model

In [19]:
```
# from tensorflow.keras.models import Sequential
# from tensorflow.keras.layers import Dense, Dropout
# from tensorflow.keras.optimizers import Adam

# Define the model (Using Selu activation for the input and hidden layers, he no
model = tf.keras.Sequential([
    tf.keras.layers.Dense(64, activation='selu', input_shape=(31,), kernel_regul
```

```
                            kernel_initializer="he_normal"),
    tf.keras.layers.Dropout(rate=0.5),
    tf.keras.layers.Dense(32, activation='selu', kernel_regularizer=l2(0.001),
                            kernel_initializer="he_normal"),
    tf.keras.layers.Dropout(rate=0.5),
    tf.keras.layers.Dense(16, activation='selu', kernel_regularizer=l2(0.001),
                            kernel_initializer="he_normal"),
    tf.keras.layers.Dropout(rate=0.5),
    tf.keras.layers.Dense(7, activation='softmax')
])

# Compile the model (Use the Nadam optimizer)
model.compile(optimizer=tf.keras.optimizers.Nadam(learning_rate=0.001),
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(X_train_transformed, y_train,
                    epochs=200,
                    batch_size=32,
                    validation_data=(X_val_transformed, y_val))
```

```
Epoch 1/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 2s 6ms/step - accuracy: 0.1526 - loss: 5.8968 - val_ac
curacy: 0.2156 - val_loss: 2.4888
Epoch 2/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.1943 - loss: 4.0776 - val_ac
curacy: 0.3104 - val_loss: 2.0745
Epoch 3/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.1975 - loss: 3.6760 - val_ac
curacy: 0.3602 - val_loss: 1.8527
Epoch 4/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.2035 - loss: 3.2383 - val_ac
curacy: 0.3886 - val_loss: 1.7308
Epoch 5/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.2270 - loss: 3.0122 - val_ac
curacy: 0.3981 - val_loss: 1.6225
Epoch 6/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.2302 - loss: 2.7376 - val_ac
curacy: 0.3957 - val_loss: 1.5469
Epoch 7/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.2879 - loss: 2.4493 - val_ac
curacy: 0.4455 - val_loss: 1.4795
Epoch 8/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.2856 - loss: 2.3422 - val_ac
curacy: 0.4810 - val_loss: 1.4060
Epoch 9/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.3242 - loss: 2.1777 - val_ac
curacy: 0.4953 - val_loss: 1.3664
Epoch 10/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.3149 - loss: 2.0868 - val_ac
curacy: 0.5545 - val_loss: 1.3098
Epoch 11/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.3233 - loss: 2.0306 - val_ac
curacy: 0.5735 - val_loss: 1.2649
Epoch 12/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.3371 - loss: 1.9837 - val_ac
curacy: 0.5806 - val_loss: 1.2268
Epoch 13/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.3619 - loss: 1.8693 - val_ac
curacy: 0.6019 - val_loss: 1.1896
Epoch 14/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.3763 - loss: 1.8114 - val_ac
curacy: 0.6090 - val_loss: 1.1680
Epoch 15/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.3892 - loss: 1.7130 - val_ac
curacy: 0.6232 - val_loss: 1.1402
Epoch 16/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.4035 - loss: 1.6426 - val_ac
curacy: 0.6114 - val_loss: 1.1204
Epoch 17/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.4345 - loss: 1.5424 - val_ac
curacy: 0.6422 - val_loss: 1.0987
Epoch 18/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.4476 - loss: 1.5552 - val_ac
curacy: 0.6374 - val_loss: 1.0923
Epoch 19/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.4343 - loss: 1.5501 - val_ac
curacy: 0.6493 - val_loss: 1.0608
Epoch 20/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.4660 - loss: 1.4829 - val_ac
curacy: 0.7062 - val_loss: 1.0262
```

```
Epoch 21/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.4571 - loss: 1.4713 - val_ac
curacy: 0.7014 - val_loss: 1.0130
Epoch 22/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.4617 - loss: 1.3924 - val_ac
curacy: 0.7109 - val_loss: 0.9949
Epoch 23/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.4556 - loss: 1.4364 - val_ac
curacy: 0.7038 - val_loss: 0.9757
Epoch 24/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.4815 - loss: 1.3731 - val_ac
curacy: 0.7204 - val_loss: 0.9627
Epoch 25/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.4904 - loss: 1.3381 - val_ac
curacy: 0.7370 - val_loss: 0.9415
Epoch 26/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.4980 - loss: 1.3154 - val_ac
curacy: 0.7299 - val_loss: 0.9315
Epoch 27/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5168 - loss: 1.2486 - val_ac
curacy: 0.7299 - val_loss: 0.9111
Epoch 28/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5605 - loss: 1.2138 - val_ac
curacy: 0.7417 - val_loss: 0.8880
Epoch 29/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5205 - loss: 1.2428 - val_ac
curacy: 0.7346 - val_loss: 0.8833
Epoch 30/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5360 - loss: 1.2423 - val_ac
curacy: 0.7299 - val_loss: 0.8681
Epoch 31/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5318 - loss: 1.2198 - val_ac
curacy: 0.7725 - val_loss: 0.8516
Epoch 32/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5613 - loss: 1.1891 - val_ac
curacy: 0.7891 - val_loss: 0.8367
Epoch 33/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5779 - loss: 1.1321 - val_ac
curacy: 0.7725 - val_loss: 0.8280
Epoch 34/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5869 - loss: 1.1264 - val_ac
curacy: 0.7773 - val_loss: 0.8176
Epoch 35/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5979 - loss: 1.0971 - val_ac
curacy: 0.7654 - val_loss: 0.8051
Epoch 36/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5875 - loss: 1.1511 - val_ac
curacy: 0.7986 - val_loss: 0.7866
Epoch 37/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5593 - loss: 1.1244 - val_ac
curacy: 0.7867 - val_loss: 0.7756
Epoch 38/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.5974 - loss: 1.0892 - val_ac
curacy: 0.7938 - val_loss: 0.7658
Epoch 39/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6067 - loss: 1.0568 - val_ac
curacy: 0.7891 - val_loss: 0.7514
Epoch 40/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.6092 - loss: 1.0740 - val_ac
curacy: 0.8033 - val_loss: 0.7365
```

```
Epoch 41/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6065 - loss: 1.0717 - val_ac
curacy: 0.8081 - val_loss: 0.7265
Epoch 42/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6305 - loss: 1.0125 - val_ac
curacy: 0.8294 - val_loss: 0.7112
Epoch 43/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6268 - loss: 1.0729 - val_ac
curacy: 0.8341 - val_loss: 0.6999
Epoch 44/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6462 - loss: 0.9884 - val_ac
curacy: 0.8246 - val_loss: 0.6885
Epoch 45/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6433 - loss: 0.9806 - val_ac
curacy: 0.8294 - val_loss: 0.6793
Epoch 46/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6386 - loss: 0.9610 - val_ac
curacy: 0.8341 - val_loss: 0.6685
Epoch 47/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6400 - loss: 0.9674 - val_ac
curacy: 0.8365 - val_loss: 0.6562
Epoch 48/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6279 - loss: 0.9954 - val_ac
curacy: 0.8673 - val_loss: 0.6511
Epoch 49/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6769 - loss: 0.9235 - val_ac
curacy: 0.8649 - val_loss: 0.6331
Epoch 50/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6460 - loss: 0.9383 - val_ac
curacy: 0.8412 - val_loss: 0.6328
Epoch 51/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6539 - loss: 0.9486 - val_ac
curacy: 0.8483 - val_loss: 0.6260
Epoch 52/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6586 - loss: 0.9411 - val_ac
curacy: 0.8697 - val_loss: 0.6149
Epoch 53/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6850 - loss: 0.8864 - val_ac
curacy: 0.8744 - val_loss: 0.6077
Epoch 54/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6855 - loss: 0.8802 - val_ac
curacy: 0.8483 - val_loss: 0.6135
Epoch 55/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6684 - loss: 0.9019 - val_ac
curacy: 0.8483 - val_loss: 0.6065
Epoch 56/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6463 - loss: 0.9033 - val_ac
curacy: 0.8626 - val_loss: 0.5871
Epoch 57/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6769 - loss: 0.8831 - val_ac
curacy: 0.8507 - val_loss: 0.5803
Epoch 58/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6529 - loss: 0.8979 - val_ac
curacy: 0.8697 - val_loss: 0.5682
Epoch 59/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6708 - loss: 0.9336 - val_ac
curacy: 0.8507 - val_loss: 0.5686
Epoch 60/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6914 - loss: 0.8475 - val_ac
curacy: 0.8626 - val_loss: 0.5612
```

```
Epoch 61/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6678 - loss: 0.8833 - val_ac
curacy: 0.8531 - val_loss: 0.5579
Epoch 62/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7154 - loss: 0.7929 - val_ac
curacy: 0.8863 - val_loss: 0.5503
Epoch 63/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6903 - loss: 0.8564 - val_ac
curacy: 0.8626 - val_loss: 0.5409
Epoch 64/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7270 - loss: 0.8002 - val_ac
curacy: 0.9052 - val_loss: 0.5473
Epoch 65/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6815 - loss: 0.8944 - val_ac
curacy: 0.8697 - val_loss: 0.5325
Epoch 66/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7149 - loss: 0.7891 - val_ac
curacy: 0.9005 - val_loss: 0.5353
Epoch 67/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7243 - loss: 0.8136 - val_ac
curacy: 0.9100 - val_loss: 0.5295
Epoch 68/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7273 - loss: 0.7757 - val_ac
curacy: 0.8815 - val_loss: 0.5174
Epoch 69/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.6879 - loss: 0.8183 - val_ac
curacy: 0.8720 - val_loss: 0.5201
Epoch 70/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7146 - loss: 0.7848 - val_ac
curacy: 0.9052 - val_loss: 0.5185
Epoch 71/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7453 - loss: 0.7598 - val_ac
curacy: 0.8673 - val_loss: 0.5104
Epoch 72/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7384 - loss: 0.7494 - val_ac
curacy: 0.9028 - val_loss: 0.4947
Epoch 73/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7084 - loss: 0.8034 - val_ac
curacy: 0.9052 - val_loss: 0.4967
Epoch 74/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7447 - loss: 0.7520 - val_ac
curacy: 0.8957 - val_loss: 0.4856
Epoch 75/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7460 - loss: 0.7104 - val_ac
curacy: 0.9052 - val_loss: 0.4785
Epoch 76/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7175 - loss: 0.7348 - val_ac
curacy: 0.8910 - val_loss: 0.4872
Epoch 77/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7394 - loss: 0.7255 - val_ac
curacy: 0.8649 - val_loss: 0.4792
Epoch 78/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7495 - loss: 0.7466 - val_ac
curacy: 0.8910 - val_loss: 0.4824
Epoch 79/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7239 - loss: 0.7237 - val_ac
curacy: 0.8744 - val_loss: 0.4821
Epoch 80/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7480 - loss: 0.7015 - val_ac
curacy: 0.8934 - val_loss: 0.4708
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Epoch 81/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7340 - loss: 0.7446 - val_ac
curacy: 0.8839 - val_loss: 0.4823
Epoch 82/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7453 - loss: 0.7161 - val_ac
curacy: 0.8910 - val_loss: 0.4761
Epoch 83/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7406 - loss: 0.7081 - val_ac
curacy: 0.8436 - val_loss: 0.4770
Epoch 84/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7642 - loss: 0.6803 - val_ac
curacy: 0.8910 - val_loss: 0.4661
Epoch 85/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.7492 - loss: 0.7279 - val_ac
curacy: 0.9408 - val_loss: 0.4424
Epoch 86/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7496 - loss: 0.7182 - val_ac
curacy: 0.9052 - val_loss: 0.4395
Epoch 87/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7654 - loss: 0.7244 - val_ac
curacy: 0.8910 - val_loss: 0.4499
Epoch 88/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7471 - loss: 0.7434 - val_ac
curacy: 0.9171 - val_loss: 0.4481
Epoch 89/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7494 - loss: 0.7379 - val_ac
curacy: 0.8957 - val_loss: 0.4482
Epoch 90/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7179 - loss: 0.7393 - val_ac
curacy: 0.8839 - val_loss: 0.4479
Epoch 91/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7803 - loss: 0.6293 - val_ac
curacy: 0.9123 - val_loss: 0.4460
Epoch 92/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7631 - loss: 0.6863 - val_ac
curacy: 0.9123 - val_loss: 0.4373
Epoch 93/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7327 - loss: 0.7247 - val_ac
curacy: 0.8839 - val_loss: 0.4391
Epoch 94/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7699 - loss: 0.6926 - val_ac
curacy: 0.9336 - val_loss: 0.4310
Epoch 95/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7638 - loss: 0.6747 - val_ac
curacy: 0.9242 - val_loss: 0.4197
Epoch 96/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7767 - loss: 0.6684 - val_ac
curacy: 0.9123 - val_loss: 0.4167
Epoch 97/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7729 - loss: 0.6614 - val_ac
curacy: 0.8957 - val_loss: 0.4202
Epoch 98/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7774 - loss: 0.6538 - val_ac
curacy: 0.9194 - val_loss: 0.4273
Epoch 99/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7713 - loss: 0.6641 - val_ac
curacy: 0.9005 - val_loss: 0.4117
Epoch 100/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7806 - loss: 0.6271 - val_ac
curacy: 0.9147 - val_loss: 0.4234
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Epoch 101/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7825 - loss: 0.6418 - val_ac
curacy: 0.9313 - val_loss: 0.4035
Epoch 102/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7590 - loss: 0.6729 - val_ac
curacy: 0.8839 - val_loss: 0.4052
Epoch 103/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7800 - loss: 0.6571 - val_ac
curacy: 0.9076 - val_loss: 0.4019
Epoch 104/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7658 - loss: 0.6499 - val_ac
curacy: 0.9313 - val_loss: 0.4056
Epoch 105/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8004 - loss: 0.6183 - val_ac
curacy: 0.9242 - val_loss: 0.4033
Epoch 106/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7750 - loss: 0.6494 - val_ac
curacy: 0.9171 - val_loss: 0.3967
Epoch 107/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7709 - loss: 0.6356 - val_ac
curacy: 0.9028 - val_loss: 0.3984
Epoch 108/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7740 - loss: 0.6352 - val_ac
curacy: 0.9313 - val_loss: 0.3913
Epoch 109/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7721 - loss: 0.6397 - val_ac
curacy: 0.9123 - val_loss: 0.3915
Epoch 110/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7817 - loss: 0.6226 - val_ac
curacy: 0.9242 - val_loss: 0.4018
Epoch 111/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7762 - loss: 0.6606 - val_ac
curacy: 0.9005 - val_loss: 0.3986
Epoch 112/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7821 - loss: 0.5907 - val_ac
curacy: 0.9242 - val_loss: 0.3907
Epoch 113/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8028 - loss: 0.5968 - val_ac
curacy: 0.8815 - val_loss: 0.3931
Epoch 114/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7639 - loss: 0.6393 - val_ac
curacy: 0.9242 - val_loss: 0.3802
Epoch 115/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7638 - loss: 0.6315 - val_ac
curacy: 0.9455 - val_loss: 0.3975
Epoch 116/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7829 - loss: 0.5789 - val_ac
curacy: 0.8981 - val_loss: 0.3845
Epoch 117/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7849 - loss: 0.6154 - val_ac
curacy: 0.9194 - val_loss: 0.3809
Epoch 118/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7947 - loss: 0.5949 - val_ac
curacy: 0.9455 - val_loss: 0.3669
Epoch 119/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7944 - loss: 0.6161 - val_ac
curacy: 0.9360 - val_loss: 0.3733
Epoch 120/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7785 - loss: 0.5961 - val_ac
curacy: 0.9171 - val_loss: 0.3734
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Epoch 121/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8006 - loss: 0.5688 - val_ac
curacy: 0.8815 - val_loss: 0.3802
Epoch 122/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7932 - loss: 0.5865 - val_ac
curacy: 0.9265 - val_loss: 0.3750
Epoch 123/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8056 - loss: 0.5817 - val_ac
curacy: 0.9123 - val_loss: 0.3817
Epoch 124/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7812 - loss: 0.6148 - val_ac
curacy: 0.8910 - val_loss: 0.3728
Epoch 125/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7679 - loss: 0.6299 - val_ac
curacy: 0.9408 - val_loss: 0.3823
Epoch 126/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7973 - loss: 0.5665 - val_ac
curacy: 0.8981 - val_loss: 0.3753
Epoch 127/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8002 - loss: 0.5795 - val_ac
curacy: 0.9147 - val_loss: 0.3733
Epoch 128/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7936 - loss: 0.5892 - val_ac
curacy: 0.9313 - val_loss: 0.3675
Epoch 129/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8073 - loss: 0.6074 - val_ac
curacy: 0.9052 - val_loss: 0.3714
Epoch 130/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7703 - loss: 0.6274 - val_ac
curacy: 0.9455 - val_loss: 0.3634
Epoch 131/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8028 - loss: 0.5892 - val_ac
curacy: 0.9171 - val_loss: 0.3673
Epoch 132/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7948 - loss: 0.5971 - val_ac
curacy: 0.9100 - val_loss: 0.3704
Epoch 133/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7921 - loss: 0.5832 - val_ac
curacy: 0.9408 - val_loss: 0.3639
Epoch 134/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8098 - loss: 0.5849 - val_ac
curacy: 0.9455 - val_loss: 0.3643
Epoch 135/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8080 - loss: 0.5775 - val_ac
curacy: 0.9123 - val_loss: 0.3629
Epoch 136/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8004 - loss: 0.5687 - val_ac
curacy: 0.9336 - val_loss: 0.3702
Epoch 137/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8172 - loss: 0.5640 - val_ac
curacy: 0.9265 - val_loss: 0.3552
Epoch 138/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7976 - loss: 0.5834 - val_ac
curacy: 0.9100 - val_loss: 0.3543
Epoch 139/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8235 - loss: 0.5894 - val_ac
curacy: 0.9550 - val_loss: 0.3493
Epoch 140/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8064 - loss: 0.5419 - val_ac
curacy: 0.9313 - val_loss: 0.3589
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Epoch 141/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8137 - loss: 0.5408 - val_ac
curacy: 0.9526 - val_loss: 0.3543
Epoch 142/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8452 - loss: 0.5028 - val_ac
curacy: 0.9123 - val_loss: 0.3762
Epoch 143/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.7897 - loss: 0.5978 - val_ac
curacy: 0.9242 - val_loss: 0.3563
Epoch 144/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.7982 - loss: 0.5687 - val_ac
curacy: 0.9123 - val_loss: 0.3755
Epoch 145/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8011 - loss: 0.5713 - val_ac
curacy: 0.9526 - val_loss: 0.3616
Epoch 146/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7924 - loss: 0.5687 - val_ac
curacy: 0.9100 - val_loss: 0.3705
Epoch 147/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7897 - loss: 0.5667 - val_ac
curacy: 0.8934 - val_loss: 0.3745
Epoch 148/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7980 - loss: 0.5776 - val_ac
curacy: 0.9147 - val_loss: 0.3639
Epoch 149/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8057 - loss: 0.5657 - val_ac
curacy: 0.9028 - val_loss: 0.3773
Epoch 150/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8116 - loss: 0.5447 - val_ac
curacy: 0.9028 - val_loss: 0.3613
Epoch 151/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8121 - loss: 0.5528 - val_ac
curacy: 0.9384 - val_loss: 0.3585
Epoch 152/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7876 - loss: 0.5713 - val_ac
curacy: 0.9384 - val_loss: 0.3598
Epoch 153/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8152 - loss: 0.5437 - val_ac
curacy: 0.9265 - val_loss: 0.3664
Epoch 154/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8212 - loss: 0.5562 - val_ac
curacy: 0.9171 - val_loss: 0.3590
Epoch 155/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8444 - loss: 0.5260 - val_ac
curacy: 0.9502 - val_loss: 0.3488
Epoch 156/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.7997 - loss: 0.5402 - val_ac
curacy: 0.9123 - val_loss: 0.3463
Epoch 157/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8166 - loss: 0.5321 - val_ac
curacy: 0.9194 - val_loss: 0.3580
Epoch 158/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - accuracy: 0.8273 - loss: 0.5095 - val_ac
curacy: 0.9218 - val_loss: 0.3475
Epoch 159/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.8262 - loss: 0.5370 - val_ac
curacy: 0.9242 - val_loss: 0.3447
Epoch 160/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.8133 - loss: 0.5449 - val_ac
curacy: 0.9028 - val_loss: 0.3515
```

```
Epoch 161/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8174 - loss: 0.5202 - val_ac
curacy: 0.9171 - val_loss: 0.3572
Epoch 162/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8372 - loss: 0.5515 - val_ac
curacy: 0.9218 - val_loss: 0.3420
Epoch 163/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8273 - loss: 0.5150 - val_ac
curacy: 0.9384 - val_loss: 0.3458
Epoch 164/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8221 - loss: 0.5156 - val_ac
curacy: 0.9171 - val_loss: 0.3623
Epoch 165/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8035 - loss: 0.5407 - val_ac
curacy: 0.9076 - val_loss: 0.3495
Epoch 166/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.7955 - loss: 0.5543 - val_ac
curacy: 0.9360 - val_loss: 0.3562
Epoch 167/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8141 - loss: 0.5208 - val_ac
curacy: 0.9408 - val_loss: 0.3473
Epoch 168/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8007 - loss: 0.5833 - val_ac
curacy: 0.9147 - val_loss: 0.3648
Epoch 169/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.7914 - loss: 0.5705 - val_ac
curacy: 0.9360 - val_loss: 0.3509
Epoch 170/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8177 - loss: 0.5578 - val_ac
curacy: 0.9479 - val_loss: 0.3441
Epoch 171/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8115 - loss: 0.5483 - val_ac
curacy: 0.9408 - val_loss: 0.3332
Epoch 172/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8034 - loss: 0.5539 - val_ac
curacy: 0.9218 - val_loss: 0.3443
Epoch 173/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8073 - loss: 0.5211 - val_ac
curacy: 0.9502 - val_loss: 0.3348
Epoch 174/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8295 - loss: 0.4963 - val_ac
curacy: 0.9550 - val_loss: 0.3412
Epoch 175/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8188 - loss: 0.5528 - val_ac
curacy: 0.9455 - val_loss: 0.3383
Epoch 176/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8085 - loss: 0.5319 - val_ac
curacy: 0.9360 - val_loss: 0.3586
Epoch 177/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.7970 - loss: 0.5498 - val_ac
curacy: 0.9526 - val_loss: 0.3474
Epoch 178/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8136 - loss: 0.5348 - val_ac
curacy: 0.9265 - val_loss: 0.3450
Epoch 179/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.7986 - loss: 0.5400 - val_ac
curacy: 0.9479 - val_loss: 0.3436
Epoch 180/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8450 - loss: 0.4933 - val_ac
curacy: 0.9194 - val_loss: 0.3800
```

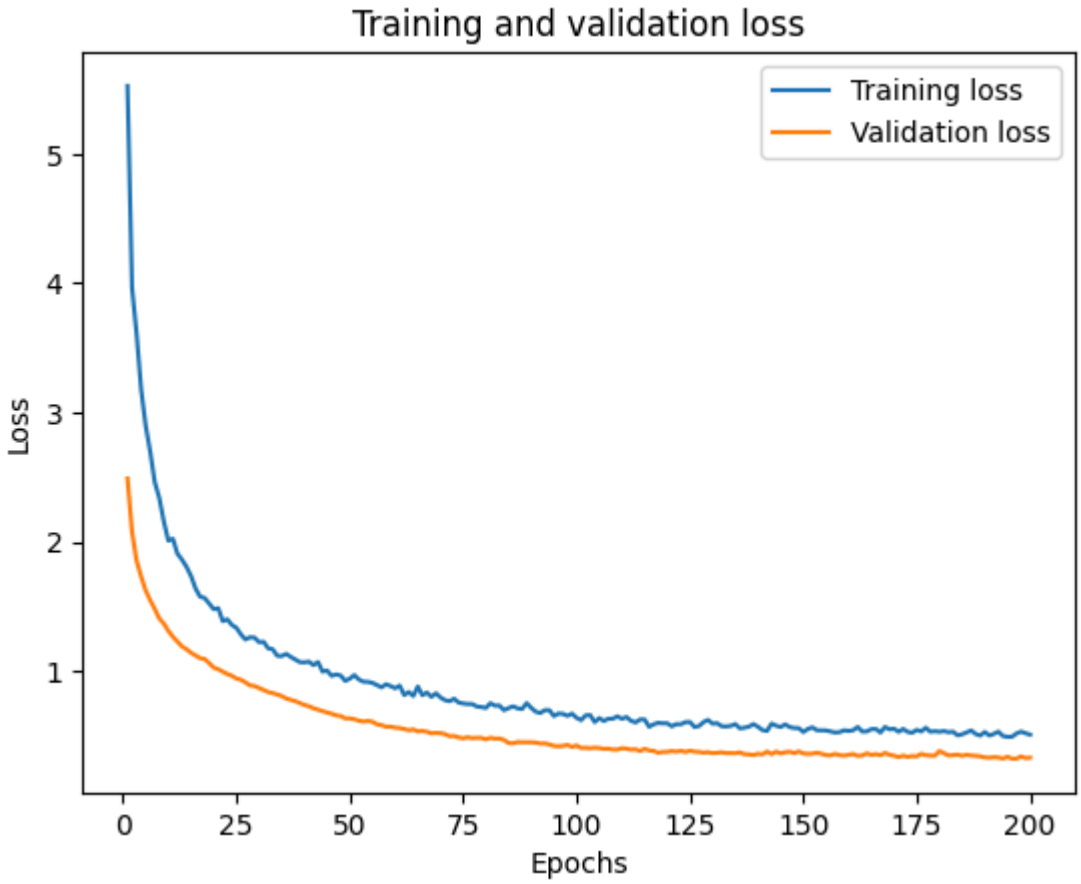
```
Epoch 181/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8106 - loss: 0.5476 - val_ac
curacy: 0.9100 - val_loss: 0.3631
Epoch 182/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8151 - loss: 0.4969 - val_ac
curacy: 0.9218 - val_loss: 0.3458
Epoch 183/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8119 - loss: 0.5392 - val_ac
curacy: 0.8957 - val_loss: 0.3483
Epoch 184/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8301 - loss: 0.4798 - val_ac
curacy: 0.9218 - val_loss: 0.3519
Epoch 185/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8172 - loss: 0.5275 - val_ac
curacy: 0.9336 - val_loss: 0.3434
Epoch 186/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8499 - loss: 0.4853 - val_ac
curacy: 0.9360 - val_loss: 0.3508
Epoch 187/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.8339 - loss: 0.5101 - val_ac
curacy: 0.9242 - val_loss: 0.3455
Epoch 188/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8174 - loss: 0.5108 - val_ac
curacy: 0.9100 - val_loss: 0.3432
Epoch 189/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8165 - loss: 0.5122 - val_ac
curacy: 0.9100 - val_loss: 0.3390
Epoch 190/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8164 - loss: 0.5099 - val_ac
curacy: 0.9455 - val_loss: 0.3305
Epoch 191/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8348 - loss: 0.4854 - val_ac
curacy: 0.9384 - val_loss: 0.3288
Epoch 192/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8277 - loss: 0.4891 - val_ac
curacy: 0.9479 - val_loss: 0.3325
Epoch 193/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8100 - loss: 0.5524 - val_ac
curacy: 0.9384 - val_loss: 0.3300
Epoch 194/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8237 - loss: 0.4896 - val_ac
curacy: 0.9408 - val_loss: 0.3216
Epoch 195/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8422 - loss: 0.4838 - val_ac
curacy: 0.9242 - val_loss: 0.3360
Epoch 196/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8311 - loss: 0.4948 - val_ac
curacy: 0.9218 - val_loss: 0.3210
Epoch 197/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8418 - loss: 0.4767 - val_ac
curacy: 0.9384 - val_loss: 0.3214
Epoch 198/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8041 - loss: 0.5333 - val_ac
curacy: 0.9194 - val_loss: 0.3386
Epoch 199/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8290 - loss: 0.5533 - val_ac
curacy: 0.9289 - val_loss: 0.3258
Epoch 200/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8084 - loss: 0.5101 - val_ac
curacy: 0.9289 - val_loss: 0.3288
```

In [ ]:
```
# Plot of training and validation loss.
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(1, len(loss) + 1)

plt.plot(epochs, loss,  label='Training loss')
plt.plot(epochs, val_loss, label='Validation loss')
plt.title('Training and validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()

plt.show()
```



Check the Test accuracy

In [21]:
```
# Test
test_loss, test_accuracy = model.evaluate(X_test_transformed, y_test)

print("Test loss {:.4f}".format(test_loss))
print("Test accuracy {:.4f}".format(test_accuracy))
```

```
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 909us/step - accuracy: 0.9575 - loss: 0.3028
Test loss 0.3041
Test accuracy 0.9433
```

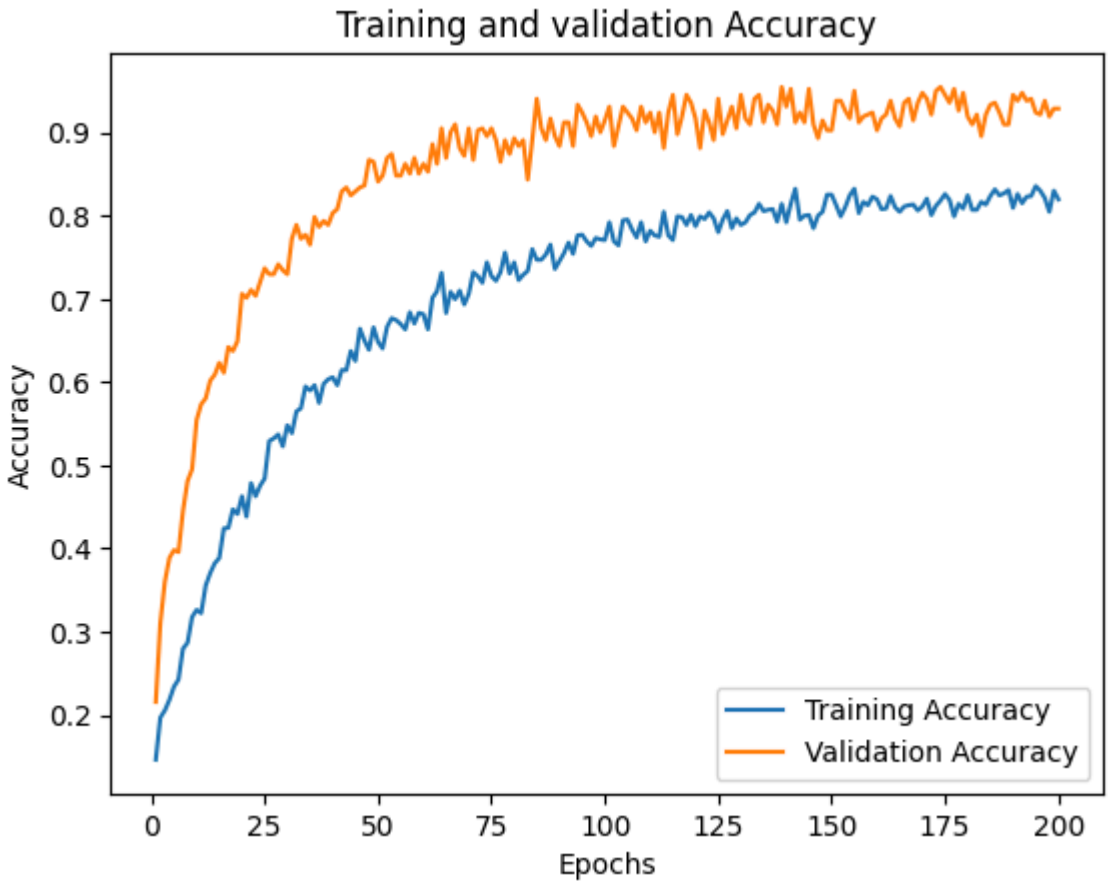
In [ ]:
```
# Plot of training and validation accuracy over epochs.

accuracy = history.history['accuracy']
val_accuracy = history.history['val_accuracy']
```

```
epochs = range(1, len(loss) + 1)

plt.plot(epochs, accuracy,  label='Training Accuracy')
plt.plot(epochs, val_accuracy, label='Validation Accuracy')
plt.title('Training and validation Accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()

plt.show()
```



Hyperparameter Tuning

In [47]:
```
# Hyperparameter Tuning: How can we better optimize our FNN? Let us start with t
# template with a custom function and test out different hyperparameters.

def skeleton_model(hp):
    n_hidden = hp.Int("n_hidden", min_value=0, max_value=10, default=2)
    n_neurons = hp.Int("n_neurons", min_value=16, max_value=256)
    learning_rate = hp.Float("learning_rate", min_value=1e-4, max_value=1e-2, sa
    optimizer = hp.Choice("optimizer", values=["Adam", "RMSProp", "Nadam", "Adam
    if optimizer == "Adam":
        optimizer = tf.keras.optimizers.Adam(learning_rate=learning_rate)
    elif optimizer == "RMSProp":
        optimizer = tf.keras.optimizers.RMSprop(learning_rate=learning_rate, rho
    elif optimizer == "Nadam":
        optimizer = tf.keras.optimizers.Nadam(learning_rate=learning_rate)
    else:
        optimizer = tf.keras.optimizers.Adamax(learning_rate=learning_rate)
```

```
    samp_model = tf.keras.Sequential()
    samp_model.add(tf.keras.layers.Flatten())
    for _ in range(n_hidden):
        samp_model.add(tf.keras.layers.Dense(n_neurons, activation="selu"))
    samp_model.add(tf.keras.layers.Dense(7, activation="softmax"))
    samp_model.compile(loss="sparse_categorical_crossentropy", optimizer=optimiz
                  metrics=["accuracy"])
    return samp_model
```

In [48]:
```
random_search_tuner = kt.RandomSearch(
    skeleton_model, objective="val_accuracy", max_trials=10, overwrite=True,
    seed=42)
random_search_tuner.search(X_train_transformed, y_train, epochs=5,
                           validation_data=(X_val_transformed, y_val))
```

```
Trial 10 Complete [00h 00m 09s]
val_accuracy: 0.8672986030578613

Best val_accuracy So Far: 0.9336493015289307
Total elapsed time: 00h 01m 26s
```

In [49]:
```
# After hyperparameter tuning trials, extract best hyperparameters from the Rand

best_trial = random_search_tuner.oracle.get_best_trials(num_trials=1)[0]
best_trial.summary()
```

```
Trial 08 summary
Hyperparameters:
n_hidden: 9
n_neurons: 124
learning_rate: 0.0005509513888645584
optimizer: Adamax
Score: 0.9336493015289307
```

Set up the alternative model using optimized hyperparameters

In [54]:
```
# Now we rerun the alternative model using the optimized hyperparameters.

model = tf.keras.Sequential([
    tf.keras.layers.Dense(124, activation='selu', input_shape=(31,), kernel_regu
                          kernel_initializer="he_normal"),
    tf.keras.layers.Dropout(rate=0.5),
    tf.keras.layers.Dense(124, activation='selu', kernel_regularizer=l2(0.001),
                          kernel_initializer="he_normal"),
    tf.keras.layers.Dropout(rate=0.5),
    tf.keras.layers.Dense(64, activation='selu', kernel_regularizer=l2(0.001),
                          kernel_initializer="he_normal"),
    tf.keras.layers.Dropout(rate=0.5),
    tf.keras.layers.Dense(32, activation='selu', kernel_regularizer=l2(0.001),
                          kernel_initializer="he_normal"),
    tf.keras.layers.Dropout(rate=0.5),
    tf.keras.layers.Dense(16, activation='selu', kernel_regularizer=l2(0.001),
                          kernel_initializer="he_normal"),
    tf.keras.layers.Dense(7, activation='softmax')
])

# Compile the final model.
model.compile(optimizer=tf.keras.optimizers.Adamax(learning_rate=0.0005509513888
```

```
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(X_train_transformed, y_train,
                    epochs=200,
                    batch_size=32,
                    validation_data=(X_val_transformed, y_val))
```

```
Epoch 1/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - accuracy: 0.1348 - loss: 9.4080 - val_a
ccuracy: 0.2678 - val_loss: 3.0923
Epoch 2/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.1621 - loss: 7.3696 - val_ac
curacy: 0.3081 - val_loss: 2.9181
Epoch 3/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.1337 - loss: 7.0938 - val_ac
curacy: 0.3175 - val_loss: 2.7987
Epoch 4/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.1567 - loss: 5.9928 - val_ac
curacy: 0.3081 - val_loss: 2.7337
Epoch 5/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.1787 - loss: 5.8552 - val_ac
curacy: 0.3152 - val_loss: 2.7066
Epoch 6/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.1585 - loss: 5.3175 - val_ac
curacy: 0.3009 - val_loss: 2.7017
Epoch 7/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.1930 - loss: 4.7836 - val_ac
curacy: 0.3128 - val_loss: 2.6871
Epoch 8/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.1809 - loss: 4.5549 - val_ac
curacy: 0.3199 - val_loss: 2.6654
Epoch 9/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.1927 - loss: 4.6150 - val_ac
curacy: 0.3199 - val_loss: 2.6607
Epoch 10/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.1830 - loss: 4.8242 - val_ac
curacy: 0.3246 - val_loss: 2.6396
Epoch 11/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.1864 - loss: 4.4841 - val_ac
curacy: 0.3318 - val_loss: 2.6228
Epoch 12/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.1827 - loss: 4.4252 - val_ac
curacy: 0.3318 - val_loss: 2.6320
Epoch 13/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 8ms/step - accuracy: 0.1864 - loss: 4.3256 - val_ac
curacy: 0.3365 - val_loss: 2.6470
Epoch 14/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.2071 - loss: 4.1642 - val_ac
curacy: 0.3341 - val_loss: 2.6425
Epoch 15/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.1943 - loss: 4.0476 - val_ac
curacy: 0.3389 - val_loss: 2.6542
Epoch 16/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.1747 - loss: 3.8990 - val_ac
curacy: 0.3389 - val_loss: 2.6533
Epoch 17/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2082 - loss: 3.7779 - val_ac
curacy: 0.3389 - val_loss: 2.6541
Epoch 18/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.1908 - loss: 3.8828 - val_ac
curacy: 0.3341 - val_loss: 2.6586
Epoch 19/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2004 - loss: 3.7121 - val_ac
curacy: 0.3365 - val_loss: 2.6578
Epoch 20/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step - accuracy: 0.1797 - loss: 3.6570 - val_ac
curacy: 0.3436 - val_loss: 2.6572
```

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Epoch 21/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.1859 - loss: 3.5613 - val_ac
curacy: 0.3483 - val_loss: 2.6398
Epoch 22/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2084 - loss: 3.5808 - val_ac
curacy: 0.3460 - val_loss: 2.6378
Epoch 23/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2310 - loss: 3.4418 - val_ac
curacy: 0.3460 - val_loss: 2.6407
Epoch 24/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.1942 - loss: 3.5441 - val_ac
curacy: 0.3436 - val_loss: 2.6405
Epoch 25/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2193 - loss: 3.4087 - val_ac
curacy: 0.3389 - val_loss: 2.6464
Epoch 26/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2420 - loss: 3.3196 - val_ac
curacy: 0.3412 - val_loss: 2.6448
Epoch 27/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2093 - loss: 3.2370 - val_ac
curacy: 0.3389 - val_loss: 2.6269
Epoch 28/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2045 - loss: 3.2529 - val_ac
curacy: 0.3483 - val_loss: 2.6175
Epoch 29/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step - accuracy: 0.2282 - loss: 3.2023 - val_ac
curacy: 0.3483 - val_loss: 2.6110
Epoch 30/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2154 - loss: 3.2349 - val_ac
curacy: 0.3578 - val_loss: 2.5830
Epoch 31/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2060 - loss: 3.1431 - val_ac
curacy: 0.3673 - val_loss: 2.5651
Epoch 32/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2228 - loss: 3.1328 - val_ac
curacy: 0.3768 - val_loss: 2.5462
Epoch 33/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2286 - loss: 3.0976 - val_ac
curacy: 0.3720 - val_loss: 2.5295
Epoch 34/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2226 - loss: 3.0552 - val_ac
curacy: 0.3673 - val_loss: 2.5147
Epoch 35/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.2356 - loss: 2.9837 - val_ac
curacy: 0.3744 - val_loss: 2.4895
Epoch 36/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2610 - loss: 2.9570 - val_ac
curacy: 0.3815 - val_loss: 2.4894
Epoch 37/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2255 - loss: 2.9276 - val_ac
curacy: 0.3839 - val_loss: 2.4667
Epoch 38/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.2655 - loss: 2.7710 - val_ac
curacy: 0.3934 - val_loss: 2.4345
Epoch 39/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.2376 - loss: 2.8624 - val_ac
curacy: 0.3957 - val_loss: 2.3962
Epoch 40/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2422 - loss: 2.8897 - val_ac
curacy: 0.4028 - val_loss: 2.3643
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Epoch 41/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2290 - loss: 2.8669 - val_ac
curacy: 0.4028 - val_loss: 2.3577
Epoch 42/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2624 - loss: 2.7678 - val_ac
curacy: 0.4100 - val_loss: 2.3192
Epoch 43/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.2415 - loss: 2.8621 - val_ac
curacy: 0.4147 - val_loss: 2.2988
Epoch 44/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.2843 - loss: 2.7312 - val_ac
curacy: 0.4194 - val_loss: 2.2782
Epoch 45/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.2869 - loss: 2.6613 - val_ac
curacy: 0.4171 - val_loss: 2.2619
Epoch 46/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.2644 - loss: 2.7148 - val_ac
curacy: 0.4242 - val_loss: 2.2379
Epoch 47/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2569 - loss: 2.7128 - val_ac
curacy: 0.4171 - val_loss: 2.2124
Epoch 48/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2623 - loss: 2.6817 - val_ac
curacy: 0.4123 - val_loss: 2.1942
Epoch 49/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2689 - loss: 2.6562 - val_ac
curacy: 0.4479 - val_loss: 2.1545
Epoch 50/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.2903 - loss: 2.5983 - val_ac
curacy: 0.4313 - val_loss: 2.1322
Epoch 51/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2986 - loss: 2.5891 - val_ac
curacy: 0.4313 - val_loss: 2.1213
Epoch 52/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.2843 - loss: 2.5852 - val_ac
curacy: 0.4336 - val_loss: 2.0775
Epoch 53/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2760 - loss: 2.6220 - val_ac
curacy: 0.4573 - val_loss: 2.0481
Epoch 54/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.3100 - loss: 2.4354 - val_ac
curacy: 0.4550 - val_loss: 2.0294
Epoch 55/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.3112 - loss: 2.4749 - val_ac
curacy: 0.4573 - val_loss: 2.0106
Epoch 56/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.3171 - loss: 2.4668 - val_ac
curacy: 0.4645 - val_loss: 2.0019
Epoch 57/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.2978 - loss: 2.4960 - val_ac
curacy: 0.4621 - val_loss: 1.9983
Epoch 58/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.3340 - loss: 2.4529 - val_ac
curacy: 0.4621 - val_loss: 1.9871
Epoch 59/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.3223 - loss: 2.4500 - val_ac
curacy: 0.4573 - val_loss: 1.9668
Epoch 60/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.3364 - loss: 2.3832 - val_ac
curacy: 0.4668 - val_loss: 1.9556
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Epoch 61/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.3057 - loss: 2.3928 - val_ac
curacy: 0.4739 - val_loss: 1.9339
Epoch 62/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.3272 - loss: 2.4114 - val_ac
curacy: 0.4716 - val_loss: 1.9108
Epoch 63/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.3250 - loss: 2.3568 - val_ac
curacy: 0.4621 - val_loss: 1.8992
Epoch 64/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.3400 - loss: 2.3117 - val_ac
curacy: 0.4668 - val_loss: 1.8934
Epoch 65/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.3229 - loss: 2.3676 - val_ac
curacy: 0.4739 - val_loss: 1.8744
Epoch 66/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.3373 - loss: 2.3183 - val_ac
curacy: 0.4810 - val_loss: 1.8582
Epoch 67/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.3191 - loss: 2.3575 - val_ac
curacy: 0.4858 - val_loss: 1.8499
Epoch 68/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.3292 - loss: 2.3382 - val_ac
curacy: 0.4739 - val_loss: 1.8343
Epoch 69/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.3404 - loss: 2.2619 - val_ac
curacy: 0.4763 - val_loss: 1.8285
Epoch 70/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.3605 - loss: 2.2525 - val_ac
curacy: 0.4834 - val_loss: 1.8144
Epoch 71/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.3625 - loss: 2.2554 - val_ac
curacy: 0.4929 - val_loss: 1.7955
Epoch 72/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.3596 - loss: 2.2345 - val_ac
curacy: 0.4882 - val_loss: 1.7841
Epoch 73/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.3657 - loss: 2.2291 - val_ac
curacy: 0.4834 - val_loss: 1.7757
Epoch 74/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.3558 - loss: 2.2594 - val_ac
curacy: 0.4882 - val_loss: 1.7723
Epoch 75/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.3693 - loss: 2.1795 - val_ac
curacy: 0.5261 - val_loss: 1.7643
Epoch 76/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.3544 - loss: 2.2273 - val_ac
curacy: 0.4787 - val_loss: 1.7603
Epoch 77/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.3926 - loss: 2.0871 - val_ac
curacy: 0.5332 - val_loss: 1.7499
Epoch 78/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.3580 - loss: 2.2064 - val_ac
curacy: 0.5355 - val_loss: 1.7491
Epoch 79/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.3761 - loss: 2.1051 - val_ac
curacy: 0.5379 - val_loss: 1.7435
Epoch 80/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.4010 - loss: 2.0830 - val_ac
curacy: 0.5427 - val_loss: 1.7398
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Epoch 81/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4211 - loss: 2.0410 - val_ac
curacy: 0.5427 - val_loss: 1.7291
Epoch 82/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.3974 - loss: 2.1084 - val_ac
curacy: 0.5237 - val_loss: 1.7267
Epoch 83/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.3977 - loss: 2.0904 - val_ac
curacy: 0.5308 - val_loss: 1.7245
Epoch 84/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4190 - loss: 2.0384 - val_ac
curacy: 0.5498 - val_loss: 1.7075
Epoch 85/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.3916 - loss: 2.0878 - val_ac
curacy: 0.5427 - val_loss: 1.6941
Epoch 86/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4187 - loss: 2.0229 - val_ac
curacy: 0.5450 - val_loss: 1.6847
Epoch 87/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4456 - loss: 2.0023 - val_ac
curacy: 0.5592 - val_loss: 1.6754
Epoch 88/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4065 - loss: 2.0461 - val_ac
curacy: 0.5474 - val_loss: 1.6709
Epoch 89/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4279 - loss: 2.0590 - val_ac
curacy: 0.5545 - val_loss: 1.6720
Epoch 90/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4286 - loss: 2.0148 - val_ac
curacy: 0.5711 - val_loss: 1.6690
Epoch 91/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.4340 - loss: 1.9561 - val_ac
curacy: 0.5592 - val_loss: 1.6550
Epoch 92/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.4137 - loss: 2.0015 - val_ac
curacy: 0.5664 - val_loss: 1.6505
Epoch 93/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.4491 - loss: 1.9456 - val_ac
curacy: 0.5545 - val_loss: 1.6414
Epoch 94/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4167 - loss: 1.9967 - val_ac
curacy: 0.5687 - val_loss: 1.6275
Epoch 95/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4219 - loss: 2.0014 - val_ac
curacy: 0.5782 - val_loss: 1.6229
Epoch 96/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4316 - loss: 1.9444 - val_ac
curacy: 0.5782 - val_loss: 1.6185
Epoch 97/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4240 - loss: 1.9365 - val_ac
curacy: 0.5687 - val_loss: 1.6075
Epoch 98/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4731 - loss: 1.8581 - val_ac
curacy: 0.5592 - val_loss: 1.5937
Epoch 99/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4834 - loss: 1.8536 - val_ac
curacy: 0.5687 - val_loss: 1.5854
Epoch 100/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.4357 - loss: 1.9092 - val_ac
curacy: 0.5735 - val_loss: 1.5803
```

```
Epoch 101/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4443 - loss: 1.9536 - val_ac
curacy: 0.5616 - val_loss: 1.5732
Epoch 102/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.4337 - loss: 1.9069 - val_ac
curacy: 0.5735 - val_loss: 1.5581
Epoch 103/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4411 - loss: 1.8939 - val_ac
curacy: 0.5853 - val_loss: 1.5403
Epoch 104/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4599 - loss: 1.8387 - val_ac
curacy: 0.5758 - val_loss: 1.5494
Epoch 105/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4884 - loss: 1.8448 - val_ac
curacy: 0.5900 - val_loss: 1.5472
Epoch 106/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4821 - loss: 1.8585 - val_ac
curacy: 0.5924 - val_loss: 1.5380
Epoch 107/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4751 - loss: 1.8260 - val_ac
curacy: 0.5948 - val_loss: 1.5284
Epoch 108/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4514 - loss: 1.8988 - val_ac
curacy: 0.5853 - val_loss: 1.5263
Epoch 109/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4618 - loss: 1.8959 - val_ac
curacy: 0.5853 - val_loss: 1.5187
Epoch 110/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4807 - loss: 1.8112 - val_ac
curacy: 0.5948 - val_loss: 1.5053
Epoch 111/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4914 - loss: 1.8329 - val_ac
curacy: 0.5924 - val_loss: 1.5063
Epoch 112/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4748 - loss: 1.7771 - val_ac
curacy: 0.5972 - val_loss: 1.5075
Epoch 113/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.4784 - loss: 1.7855 - val_ac
curacy: 0.6043 - val_loss: 1.5067
Epoch 114/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5170 - loss: 1.7696 - val_ac
curacy: 0.5948 - val_loss: 1.4955
Epoch 115/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.4945 - loss: 1.8007 - val_ac
curacy: 0.5948 - val_loss: 1.4798
Epoch 116/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4903 - loss: 1.7954 - val_ac
curacy: 0.6090 - val_loss: 1.4677
Epoch 117/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.4805 - loss: 1.7755 - val_ac
curacy: 0.6209 - val_loss: 1.4645
Epoch 118/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4827 - loss: 1.7994 - val_ac
curacy: 0.6209 - val_loss: 1.4489
Epoch 119/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4757 - loss: 1.7743 - val_ac
curacy: 0.6303 - val_loss: 1.4389
Epoch 120/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4651 - loss: 1.7548 - val_ac
curacy: 0.6564 - val_loss: 1.4276
```

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Epoch 121/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5349 - loss: 1.6996 - val_ac
curacy: 0.6493 - val_loss: 1.4306
Epoch 122/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5216 - loss: 1.6809 - val_ac
curacy: 0.6588 - val_loss: 1.4218
Epoch 123/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5001 - loss: 1.7173 - val_ac
curacy: 0.6659 - val_loss: 1.4098
Epoch 124/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4851 - loss: 1.7491 - val_ac
curacy: 0.6611 - val_loss: 1.4071
Epoch 125/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.5036 - loss: 1.7265 - val_ac
curacy: 0.6398 - val_loss: 1.4129
Epoch 126/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5007 - loss: 1.7110 - val_ac
curacy: 0.6445 - val_loss: 1.4117
Epoch 127/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5039 - loss: 1.7162 - val_ac
curacy: 0.6540 - val_loss: 1.3948
Epoch 128/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5131 - loss: 1.6879 - val_ac
curacy: 0.6588 - val_loss: 1.3899
Epoch 129/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.4816 - loss: 1.7185 - val_ac
curacy: 0.6754 - val_loss: 1.3890
Epoch 130/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5022 - loss: 1.6576 - val_ac
curacy: 0.6872 - val_loss: 1.3687
Epoch 131/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5201 - loss: 1.6764 - val_ac
curacy: 0.7156 - val_loss: 1.3500
Epoch 132/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5092 - loss: 1.7117 - val_ac
curacy: 0.7109 - val_loss: 1.3510
Epoch 133/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5481 - loss: 1.6343 - val_ac
curacy: 0.7085 - val_loss: 1.3449
Epoch 134/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.5092 - loss: 1.6702 - val_ac
curacy: 0.7227 - val_loss: 1.3370
Epoch 135/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5073 - loss: 1.6430 - val_ac
curacy: 0.7180 - val_loss: 1.3332
Epoch 136/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5225 - loss: 1.6085 - val_ac
curacy: 0.7014 - val_loss: 1.3368
Epoch 137/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5798 - loss: 1.6218 - val_ac
curacy: 0.6919 - val_loss: 1.3347
Epoch 138/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5429 - loss: 1.6172 - val_ac
curacy: 0.7038 - val_loss: 1.3258
Epoch 139/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5287 - loss: 1.6755 - val_ac
curacy: 0.7227 - val_loss: 1.3040
Epoch 140/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5317 - loss: 1.6665 - val_ac
curacy: 0.7109 - val_loss: 1.3013
```

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Epoch 141/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5508 - loss: 1.5745 - val_ac
curacy: 0.7062 - val_loss: 1.2881
Epoch 142/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5748 - loss: 1.5677 - val_ac
curacy: 0.7038 - val_loss: 1.2884
Epoch 143/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5343 - loss: 1.5927 - val_ac
curacy: 0.7085 - val_loss: 1.2848
Epoch 144/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.5044 - loss: 1.6162 - val_ac
curacy: 0.7227 - val_loss: 1.2717
Epoch 145/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5272 - loss: 1.6192 - val_ac
curacy: 0.7180 - val_loss: 1.2605
Epoch 146/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5531 - loss: 1.5545 - val_ac
curacy: 0.7227 - val_loss: 1.2550
Epoch 147/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.5809 - loss: 1.5484 - val_ac
curacy: 0.7275 - val_loss: 1.2578
Epoch 148/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5122 - loss: 1.5999 - val_ac
curacy: 0.7275 - val_loss: 1.2552
Epoch 149/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5567 - loss: 1.5776 - val_ac
curacy: 0.7322 - val_loss: 1.2479
Epoch 150/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5400 - loss: 1.6182 - val_ac
curacy: 0.7370 - val_loss: 1.2357
Epoch 151/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5467 - loss: 1.5767 - val_ac
curacy: 0.7441 - val_loss: 1.2363
Epoch 152/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5160 - loss: 1.5688 - val_ac
curacy: 0.7393 - val_loss: 1.2340
Epoch 153/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.5637 - loss: 1.5398 - val_ac
curacy: 0.7417 - val_loss: 1.2286
Epoch 154/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5521 - loss: 1.5295 - val_ac
curacy: 0.7678 - val_loss: 1.2206
Epoch 155/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5908 - loss: 1.5007 - val_ac
curacy: 0.7725 - val_loss: 1.2085
Epoch 156/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5221 - loss: 1.6007 - val_ac
curacy: 0.7749 - val_loss: 1.2019
Epoch 157/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5678 - loss: 1.5307 - val_ac
curacy: 0.7464 - val_loss: 1.2049
Epoch 158/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5546 - loss: 1.5569 - val_ac
curacy: 0.7867 - val_loss: 1.1892
Epoch 159/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5918 - loss: 1.4930 - val_ac
curacy: 0.8009 - val_loss: 1.1847
Epoch 160/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5800 - loss: 1.4780 - val_ac
curacy: 0.7867 - val_loss: 1.1826
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Epoch 161/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5715 - loss: 1.5228 - val_ac
curacy: 0.7559 - val_loss: 1.1823
Epoch 162/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5801 - loss: 1.4902 - val_ac
curacy: 0.7536 - val_loss: 1.1872
Epoch 163/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5645 - loss: 1.5100 - val_ac
curacy: 0.7654 - val_loss: 1.1774
Epoch 164/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5749 - loss: 1.4728 - val_ac
curacy: 0.7725 - val_loss: 1.1635
Epoch 165/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.5975 - loss: 1.4304 - val_ac
curacy: 0.7938 - val_loss: 1.1542
Epoch 166/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5955 - loss: 1.4832 - val_ac
curacy: 0.7701 - val_loss: 1.1680
Epoch 167/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.5893 - loss: 1.4742 - val_ac
curacy: 0.7773 - val_loss: 1.1535
Epoch 168/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5864 - loss: 1.4896 - val_ac
curacy: 0.7583 - val_loss: 1.1552
Epoch 169/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5940 - loss: 1.4903 - val_ac
curacy: 0.7654 - val_loss: 1.1539
Epoch 170/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.5819 - loss: 1.4474 - val_ac
curacy: 0.7701 - val_loss: 1.1511
Epoch 171/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5993 - loss: 1.4968 - val_ac
curacy: 0.8009 - val_loss: 1.1413
Epoch 172/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5740 - loss: 1.5023 - val_ac
curacy: 0.7749 - val_loss: 1.1440
Epoch 173/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5859 - loss: 1.4893 - val_ac
curacy: 0.7796 - val_loss: 1.1338
Epoch 174/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.5851 - loss: 1.4369 - val_ac
curacy: 0.7844 - val_loss: 1.1332
Epoch 175/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.5948 - loss: 1.4613 - val_ac
curacy: 0.7844 - val_loss: 1.1280
Epoch 176/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5837 - loss: 1.4674 - val_ac
curacy: 0.7938 - val_loss: 1.1278
Epoch 177/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.5775 - loss: 1.5007 - val_ac
curacy: 0.8128 - val_loss: 1.1165
Epoch 178/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5992 - loss: 1.4164 - val_ac
curacy: 0.7986 - val_loss: 1.1168
Epoch 179/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.5835 - loss: 1.4629 - val_ac
curacy: 0.7796 - val_loss: 1.1149
Epoch 180/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6009 - loss: 1.4278 - val_ac
curacy: 0.8223 - val_loss: 1.1007
```

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Epoch 181/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6026 - loss: 1.4202 - val_ac
curacy: 0.8104 - val_loss: 1.0998
Epoch 182/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.6136 - loss: 1.4573 - val_ac
curacy: 0.7725 - val_loss: 1.1088
Epoch 183/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5866 - loss: 1.4625 - val_ac
curacy: 0.8033 - val_loss: 1.0968
Epoch 184/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6193 - loss: 1.4422 - val_ac
curacy: 0.8318 - val_loss: 1.0845
Epoch 185/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5780 - loss: 1.4142 - val_ac
curacy: 0.8057 - val_loss: 1.0878
Epoch 186/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.6476 - loss: 1.3564 - val_ac
curacy: 0.8175 - val_loss: 1.0767
Epoch 187/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.6196 - loss: 1.4202 - val_ac
curacy: 0.8152 - val_loss: 1.0764
Epoch 188/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5906 - loss: 1.4158 - val_ac
curacy: 0.8175 - val_loss: 1.0755
Epoch 189/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6384 - loss: 1.3761 - val_ac
curacy: 0.8009 - val_loss: 1.0812
Epoch 190/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6059 - loss: 1.3797 - val_ac
curacy: 0.8152 - val_loss: 1.0775
Epoch 191/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6020 - loss: 1.3682 - val_ac
curacy: 0.8033 - val_loss: 1.0734
Epoch 192/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.5970 - loss: 1.3743 - val_ac
curacy: 0.8365 - val_loss: 1.0587
Epoch 193/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6263 - loss: 1.4105 - val_ac
curacy: 0.8294 - val_loss: 1.0621
Epoch 194/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step - accuracy: 0.6237 - loss: 1.3645 - val_ac
curacy: 0.8175 - val_loss: 1.0585
Epoch 195/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.6490 - loss: 1.3104 - val_ac
curacy: 0.8389 - val_loss: 1.0449
Epoch 196/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.6595 - loss: 1.3541 - val_ac
curacy: 0.8294 - val_loss: 1.0442
Epoch 197/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6412 - loss: 1.3310 - val_ac
curacy: 0.8294 - val_loss: 1.0493
Epoch 198/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6268 - loss: 1.3468 - val_ac
curacy: 0.8009 - val_loss: 1.0579
Epoch 199/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6498 - loss: 1.3268 - val_ac
curacy: 0.8033 - val_loss: 1.0487
Epoch 200/200
40/40 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6186 - loss: 1.3301 - val_ac
curacy: 0.8270 - val_loss: 1.0349
```

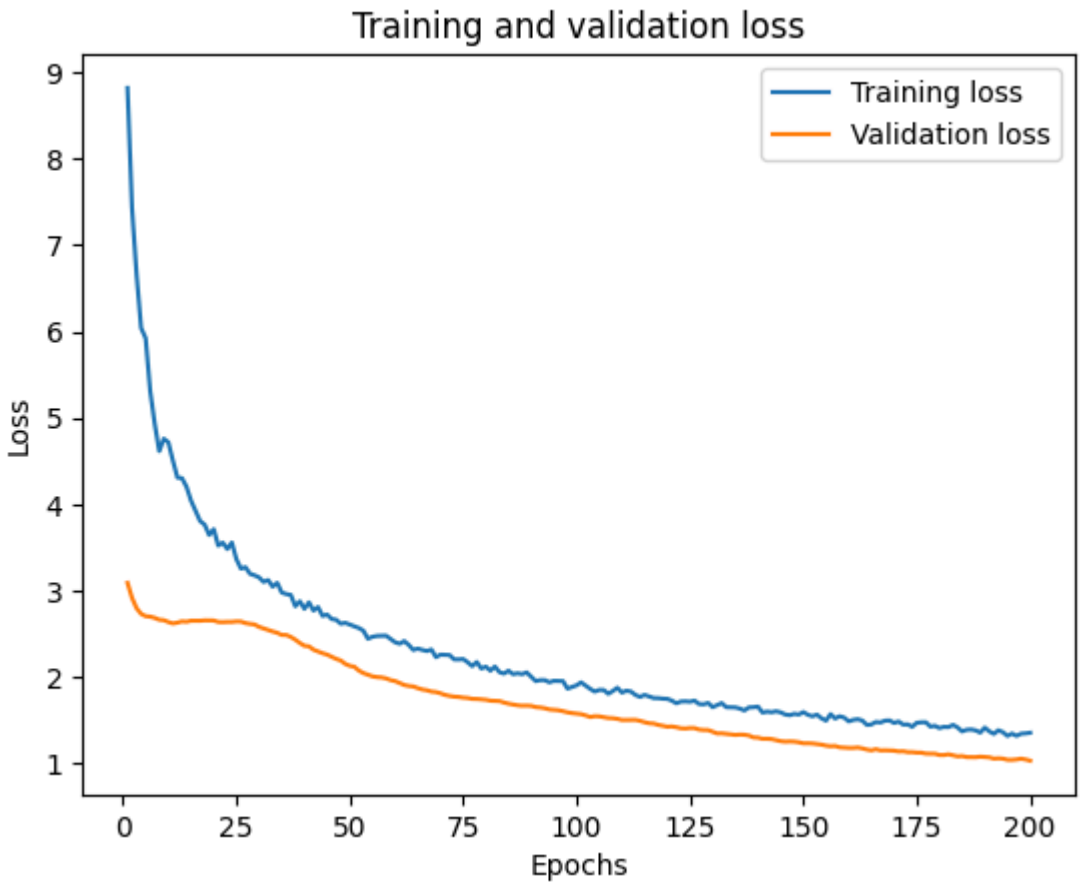
In [55]:
```
# Plot of training and validation loss of the final model.

loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(1, len(loss) + 1)

plt.plot(epochs, loss,  label='Training loss')
plt.plot(epochs, val_loss, label='Validation loss')
plt.title('Training and validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()

plt.show()
```



Check the test accuracy for the alternative model

In [56]:
```
# Test accuracy and loss for the final model.

test_loss, test_accuracy = model.evaluate(X_test_transformed, y_test)

print("Test loss {:.4f}".format(test_loss))
print("Test accuracy {:.4f}".format(test_accuracy))
```

```
14/14 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.8918 - loss: 1.0025
Test loss 0.9870
Test accuracy 0.9031
```

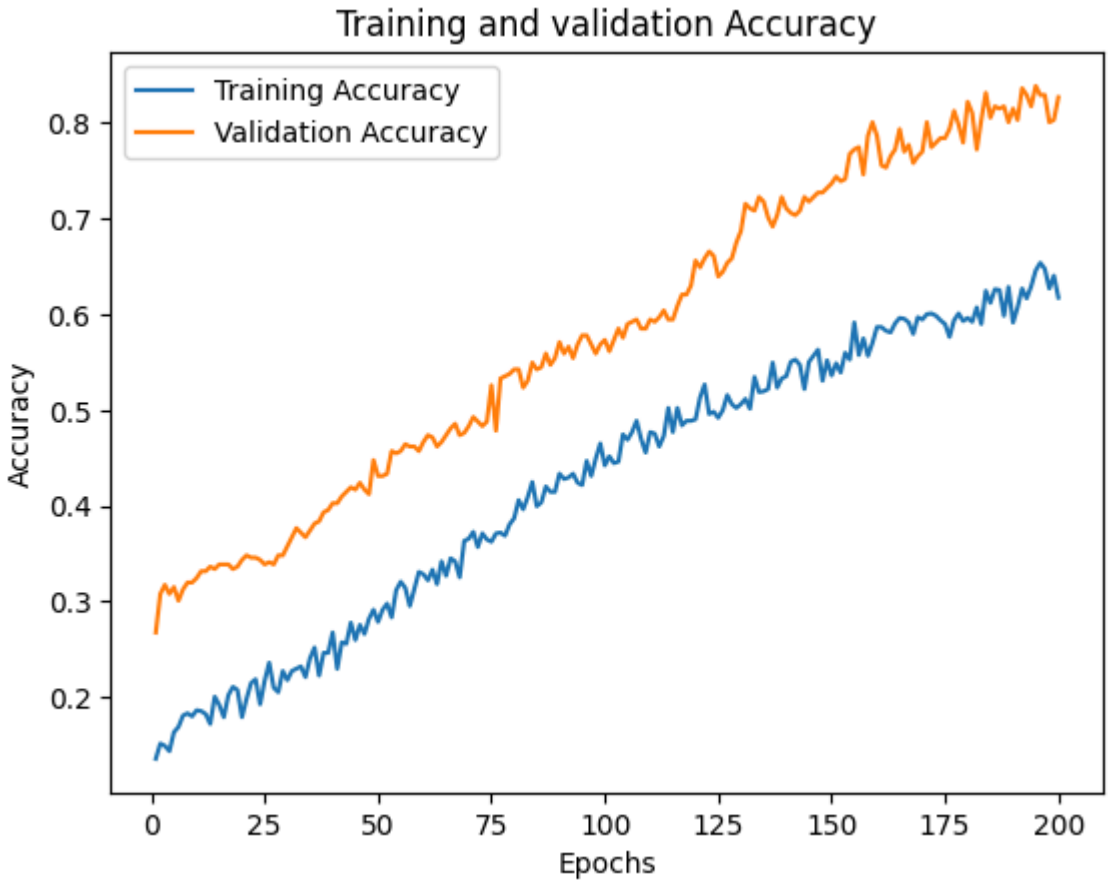
In [57]:
```
# Plot of training and validation accuracy over epochs for the final model.

accuracy = history.history['accuracy']
val_accuracy = history.history['val_accuracy']

epochs = range(1, len(loss) + 1)

plt.plot(epochs, accuracy,  label='Training Accuracy')
plt.plot(epochs, val_accuracy, label='Validation Accuracy')
plt.title('Training and validation Accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()

plt.show()
```



Even with hyperparameter tuning, our original model yielded a better test accuracy and test loss overall, hence we will use it as our true final model. (94.33% is the best we could do even with hyperparameter tuning).

In [ ]: