Для вашего проекта решите указанные задачи.

1) Используя табличные данные части №1, решите задачу регрессии с помощью нейронных сетей.

- Рассмотрите минимум 3 архитектуры нейронной сети с минимум 3 разными параметрами модели и обучения.
- Визуализируйте архитектуры моделей.
- Постройте графики зависимости значений метрик и функции потерь от номера эпохи.
- Выберите лучшую модель.
- Настройте гиперпараметры модели и определите метрики работы модели при этих значениях.
- Оцените качество работы модели на тестовых данных и оцените недообучение и переобучение.

2) Используя табличные данные части №1, повторите действия п.1, решив задачу классификации.

3) Возьмите датасет или изображений, или видео, или текстов, или звуковых/речевых данных, которые связаны с вашим проектом и нужны для решения задач проекта или создания нового умного функционала продукта/сервиса проекта.

- Проведите обработку взятых данных с помощью нейронных сетей (аналогично предыдущим пунктам).
- Выполните п.3, используя AutoKeras.

*Если ваш проект связан с рекомендательными системами или обучением с подкреплением, то можно адаптировать/изменить п.3 для решения такой задачи.

Описание проекта:

Будем работать с датасетом физической активности, которую собирает приложение о туристических маршрутах.

В этом датасете собраны данные 30 человек, выполняющих различные действия со смартфоном на поясе. Данные записывались с помощью датчиков (акселерометра и гироскопа) в этом смартфоне. Были зафиксированы: "3-осевое линейное ускорение" (tAcc-XYZ) и "3-осевая угловая скорость" (tGyro-XYZ).

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
```

```
train = pd.read_csv('train.csv')
test = pd.read_csv('test.csv')
```

```
# Проверка на пропуски
print("Пропуски в тренировочном наборе данных:")
print(train.isnull().sum().sum())
print("\nПропуски в тестовом наборе данных:")
print(test.isnull().sum().sum())
```

```
Пропуски в тренировочном наборе данных:
0

Пропуски в тестовом наборе данных:
0
```

```
# Проверка типов данных
print("\nТипы данных в тренировочном наборе:")
print(train.dtypes)
print("\nТипы данных в тестовом наборе:")
print(test.dtypes)
```

```

Типы данных в тренировочном наборе:
tBodyAcc-mean()-X       float64
tBodyAcc-mean()-Y       float64
tBodyAcc-mean()-Z       float64
tBodyAcc-std()-X        float64
tBodyAcc-std()-Y        float64
                         ...
angle(X,gravityMean)    float64
angle(Y,gravityMean)    float64
angle(Z,gravityMean)    float64
subject                   int64
Activity                 object
Length: 563, dtype: object

Типы данных в тестовом наборе:
tBodyAcc-mean()-X       float64
tBodyAcc-mean()-Y       float64
tBodyAcc-mean()-Z       float64
tBodyAcc-std()-X        float64
```

```
tBodyAcc-std()-Y        float64
                         ...
angle(X,gravityMean)    float64
angle(Y,gravityMean)    float64
angle(Z,gravityMean)    float64
subject                   int64
Activity                 object
Length: 563, dtype: object
```

```
# Проверка на дубликаты
print("\nДубликаты в тренировочном наборе:")
print(train.duplicated().sum())
print("\nДубликаты в тестовом наборе:")
print(test.duplicated().sum())
```

```
Дубликаты в тренировочном наборе:
0

Дубликаты в тестовом наборе:
0
```

```
# Проверка статистических данных
print("\nОписательная статистика тренировочного набора:")
print(train.describe())
print("\nОписательная статистика тестового набора:")
print(test.describe())
```

```
Описательная статистика тренировочного набора:
       tBodyAcc-mean()-X  tBodyAcc-mean()-Y  tBodyAcc-mean()-Z  \
count        7352.000000        7352.000000        7352.000000   
mean            0.274488          -0.017695          -0.109141   
std             0.070261           0.040811           0.056635   
min            -1.000000          -1.000000          -1.000000   
25%             0.262975          -0.024863          -0.120993   
50%             0.277193          -0.017219          -0.108676   
75%             0.288461          -0.010783          -0.097794   
max             1.000000           1.000000           1.000000   

       tBodyAcc-std()-X  tBodyAcc-std()-Y  tBodyAcc-std()-Z  tBodyAcc-mad()-X  \
count       7352.000000       7352.000000       7352.000000       7352.000000   
mean          -0.605438         -0.510938         -0.604754         -0.630512   
std            0.448734          0.502645          0.418687          0.424073   
min           -1.000000         -0.999873         -1.000000         -1.000000   
25%           -0.992754         -0.978129         -0.980233         -0.993591   
50%           -0.946196         -0.851897         -0.859365         -0.950709   
75%           -0.242813         -0.034231         -0.262415         -0.292680   
max            1.000000          0.916238          1.000000          1.000000   

       tBodyAcc-mad()-Y  tBodyAcc-mad()-Z  tBodyAcc-max()-X  ...  \
count       7352.000000       7352.000000       7352.000000  ...   
mean          -0.526907         -0.606150         -0.468604  ...   
std            0.485942          0.414122          0.544547  ...   
min           -1.000000         -1.000000         -1.000000  ...   
25%           -0.978162         -0.980251         -0.936219  ...   
50%           -0.857328         -0.857143         -0.881637  ...   
75%           -0.066701         -0.265671         -0.017129  ...   
max            0.967664          1.000000          1.000000  ...   

       fBodyBodyGyroJerkMag-skewness()  fBodyBodyGyroJerkMag-kurtosis()  \
count                      7352.000000                      7352.000000   
mean                         -0.307009                        -0.625294   
std                           0.321011                         0.307584   
min                          -0.995357                        -0.999765   
25%                          -0.542602                        -0.845573   
50%                          -0.343685                        -0.711692   
75%                          -0.126979                        -0.503878   
max                           0.989538                         0.956845   

       angle(tBodyAccMean,gravity)  angle(tBodyAccJerkMean),gravityMean)  \
count                  7352.000000                           7352.000000   
mean                      0.008684                              0.002186   
std                       0.336787                              0.448306   
min                      -0.976580                             -1.000000   
25%                      -0.121527                             -0.289549   
50%                       0.009509                              0.008943   
75%                       0.150865                              0.292861   
max                       1.000000                              1.000000   

       angle(tBodyGyroMean,gravityMean)  angle(tBodyGyroJerkMean,gravityMean)  \
count                       7352.000000                           7352.000000   
mean                           0.008726                             -0.005981   
std                            0.608303                              0.477975   
min                           -1.000000                             -1.000000   
25%                           -0.482273                             -0.376341   
```

```
train.head()
```

	tBodyAcc-mean()-X	tBodyAcc-mean()-Y	tBodyAcc-mean()-Z	tBodyAcc-std()-X	tBodyAcc-std()-Y	tBodyAcc-std()-Z	tBodyAcc-mad()-X	tBodyAcc-mad()-Y	tBodyAcc-mad()-Z	tBodyAcc-max()-X	...	fBodyBodyGyroJe kurt
0	0.288585	-0.020294	-0.132905	-0.995279	-0.983111	-0.913526	-0.995112	-0.983185	-0.923527	-0.934724	...	-0.
1	0.278419	-0.016411	-0.123520	-0.998245	-0.975300	-0.960322	-0.998807	-0.974914	-0.957686	-0.943068	...	-0.
2	0.279653	-0.019467	-0.113462	-0.995380	-0.967187	-0.978944	-0.996520	-0.963668	-0.977469	-0.938692	...	-0.
3	0.279174	-0.026201	-0.123283	-0.996091	-0.983403	-0.990675	-0.997099	-0.982750	-0.989302	-0.938692	...	-0.
4	0.276629	-0.016570	-0.115362	-0.998139	-0.980817	-0.990482	-0.998321	-0.979672	-0.990441	-0.942469	...	-0.

5 rows × 563 columns

```
test.head()
```

	tBodyAcc-mean()-X	tBodyAcc-mean()-Y	tBodyAcc-mean()-Z	tBodyAcc-std()-X	tBodyAcc-std()-Y	tBodyAcc-std()-Z	tBodyAcc-mad()-X	tBodyAcc-mad()-Y	tBodyAcc-mad()-Z	tBodyAcc-max()-X	...	fBodyBodyGyroJe kurt
0	0.257178	-0.023285	-0.014654	-0.938404	-0.920091	-0.667683	-0.952501	-0.925249	-0.674302	-0.894088	...	-0.
1	0.286027	-0.013163	-0.119083	-0.975415	-0.967458	-0.944958	-0.986799	-0.968401	-0.945823	-0.894088	...	-0.
2	0.275485	-0.026050	-0.118152	-0.993819	-0.969926	-0.962748	-0.994403	-0.970735	-0.963483	-0.939260	...	-0.
3	0.270298	-0.032614	-0.117520	-0.994743	-0.973268	-0.967091	-0.995274	-0.974471	-0.968897	-0.938610	...	-0.
4	0.274833	-0.027848	-0.129527	-0.993852	-0.967445	-0.978295	-0.994111	-0.965953	-0.977346	-0.938610	...	-0.

5 rows × 563 columns

```
# Вывод всех признаков тренировочного набора данных
print("Признаки тренировочного набора данных:")
int(train.columns.tolist())

# Вывод всех признаков тестового набора данных
print("\nПризнаки тестового набора данных:")
print(test.columns.tolist())
```

```
Признаки тренировочного набора данных:
['tBodyAcc-mean()-X', 'tBodyAcc-mean()-Y', 'tBodyAcc-mean()-Z', 'tBodyAcc-std()-X', 'tBodyAcc-std()-Y', 'tBodyAcc-std()-Z', 'tBodyAc

Признаки тестового набора данных:
['tBodyAcc-mean()-X', 'tBodyAcc-mean()-Y', 'tBodyAcc-mean()-Z', 'tBodyAcc-std()-X', 'tBodyAcc-std()-Y', 'tBodyAcc-std()-Z', 'tBodyAc
```

1) Задача регрессии с помощью нейронных сетей

Архитектура 1: Простая полносвязная сеть

За целевую переменную возьмем например tBodyAcc-max()-X

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

```
y_train = train["tBodyAcc-max()-X"]
y_test = test["tBodyAcc-max()-X"]
```

```
X_train = train[["tBodyAccMag-mean()","tBodyGyroJerk-mad()-X","tGravityAcc-min()-X","fBodyAcc-bandsEnergy()-1,8.2","angle(X,gravityMean)","ang
X_test = test[["tBodyAccMag-mean()","tBodyGyroJerk-mad()-X","tGravityAcc-min()-X","fBodyAcc-bandsEnergy()-1,8.2","angle(X,gravityMean)","angle
```

```
# Архитектура модели
model_1 = Sequential()
model_1.add(Dense(64, input_dim=X_train.shape[1], activation='relu'))
model_1.add(Dense(1, activation='linear'))

# Компиляция модели
model_1.compile(optimizer='adam', loss='mean_squared_error', metrics=['mae'])

# Обучение модели
history_1 = model_1.fit(X_train, y_train, epochs=100, batch_size=32, validation_split=0.2, verbose=0)
```

```
# Оценка модели
eval_result = model_1.evaluate(X_test, y_test)
print("[test loss, test mae]:", eval_result)
```

```
93/93 [==============================] - 0s 2ms/step - loss: 0.0189 - mae: 0.0803
[test loss, test mae]: [0.018851246684789658, 0.08025195449590683]
```

Архитектура 2: Глубокая полносвязная сеть

```
# Архитектура модели
model_2 = Sequential()
model_2.add(Dense(128, input_dim=X_train.shape[1], activation='relu'))
model_2.add(Dense(64, activation='relu'))
model_2.add(Dense(64, activation='relu'))
model_2.add(Dense(64, activation='relu'))
model_2.add(Dense(64, activation='relu'))
model_2.add(Dense(32, activation='relu'))
model_2.add(Dense(1, activation='linear'))

# Компиляция модели
model_2.compile(optimizer='sgd', loss='mean_squared_error', metrics=['mae'])

# Обучение модели
history_2 = model_2.fit(X_train, y_train, epochs=100, batch_size=64, validation_split=0.2, verbose=0)

```

```
# Оценка модели
eval_result = model_2.evaluate(X_test, y_test)
print("[test loss, test mae]:", eval_result)
```

```
93/93 [==============================] - 0s 3ms/step - loss: 0.0147 - mae: 0.0739
[test loss, test mae]: [0.01474537793546915, 0.07393579185009003]
```

Архитектура 3: Сеть с регуляризацией

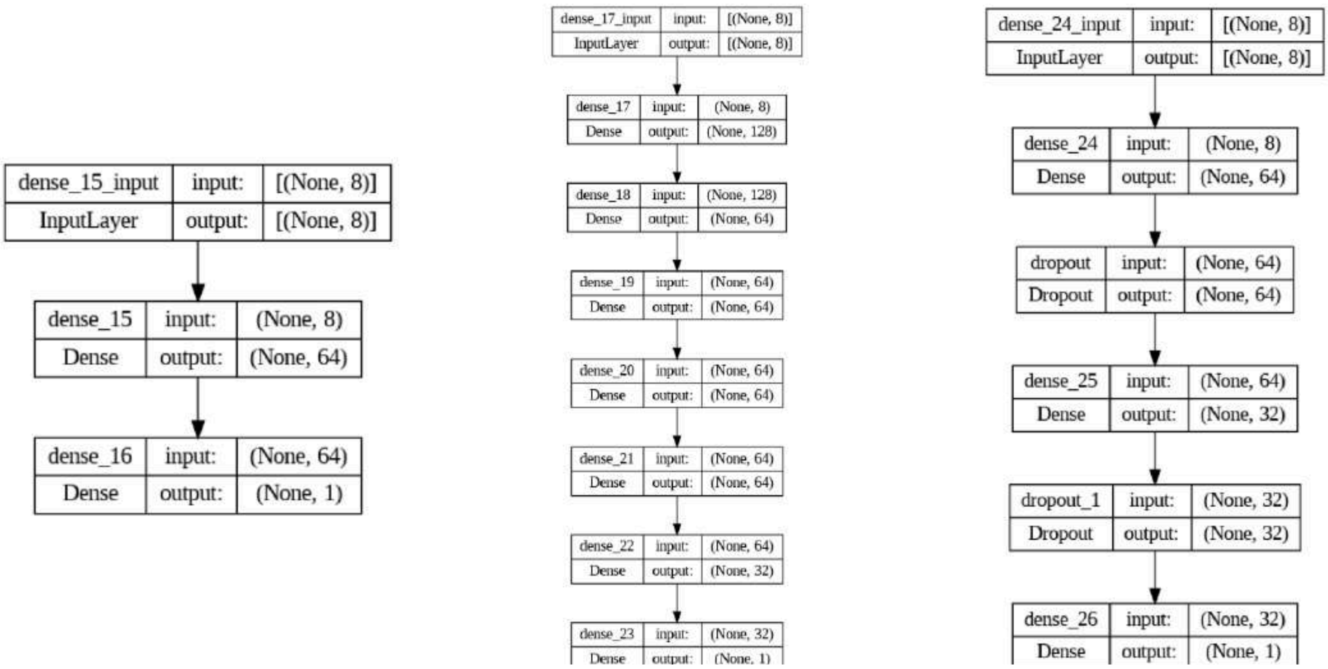
```
from keras.layers import Dropout
from keras.regularizers import l2

# Архитектура модели
model_3 = Sequential()
model_3.add(Dense(64, input_dim=X_train.shape[1], activation='relu', kernel_regularizer=l2(0.01)))
model_3.add(Dropout(0.5))
model_3.add(Dense(32, activation='relu', kernel_regularizer=l2(0.01)))
model_3.add(Dropout(0.5))
model_3.add(Dense(1, activation='linear'))

# Компиляция модели
model_3.compile(optimizer='rmsprop', loss='mean_squared_error', metrics=['mae'])

# Обучение модели
history_3 = model_3.fit(X_train, y_train, epochs=100, batch_size=32, validation_split=0.2, verbose=0)

```

```
# Оценка модели
eval_result = model_3.evaluate(X_test, y_test)
print("[test loss, test mae]:", eval_result)
```

```
93/93 [==============================] - 0s 2ms/step - loss: 0.0293 - mae: 0.1102
[test loss, test mae]: [0.029261024668812752, 0.1101958230137825]
```

Визуализация архитектур моделей

```python
from tensorflow.keras.utils import plot_model
from IPython.display import Image
import matplotlib.image as mpimg

# Сохранение визуализаций архитектур моделей в файлы
plot_model(model_1, to_file='model_1.png', show_shapes=True, show_layer_names=True)
plot_model(model_2, to_file='model_2.png', show_shapes=True, show_layer_names=True)
plot_model(model_3, to_file='model_3.png', show_shapes=True, show_layer_names=True)

# Отображение изображений архитектур моделей на одном plot
fig, axs = plt.subplots(1, 3, figsize=(20, 10))

# Отображение модели 1
img_1 = mpimg.imread('model_1.png')
axs[0].imshow(img_1)
axs[0].axis('off')  # Скрыть оси

# Отображение модели 2
img_2 = mpimg.imread('model_2.png')
axs[1].imshow(img_2)
axs[1].axis('off')

# Отображение модели 3
img_3 = mpimg.imread('model_3.png')
axs[2].imshow(img_3)
axs[2].axis('off')

plt.show()
```

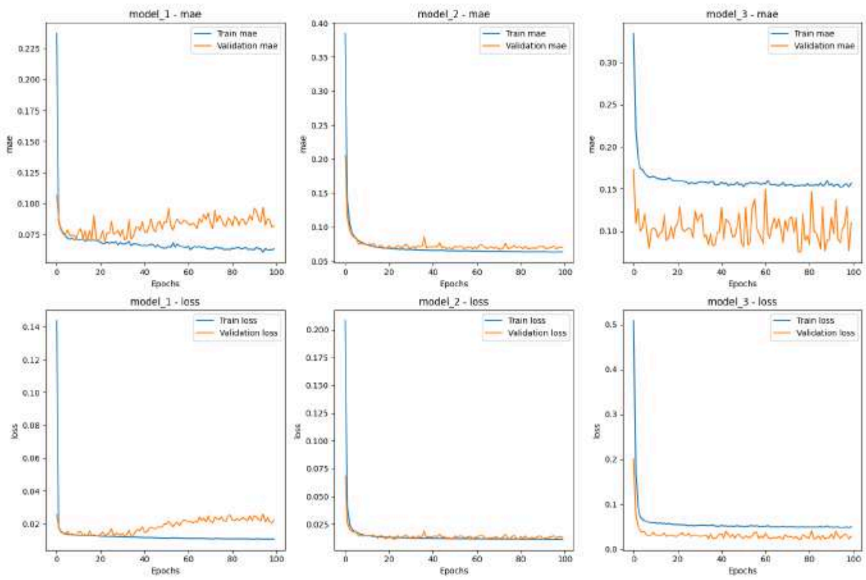


Визуализация метрик и функции потерь

Для построения графиков зависимости метрик и функции потерь от номера эпохи

```python
def plot_all_metrics(histories, metric_names):
    fig, axes = plt.subplots(nrows=len(metric_names), ncols=len(histories), figsize=(15, 10))

    for col, (model_name, history) in enumerate(histories.items()):
        for row, metric_name in enumerate(metric_names):
            axes[row, col].plot(history.history[metric_name], label=f'Train {metric_name}')
            axes[row, col].plot(history.history[f'val_{metric_name}'], label=f'Validation {metric_name}')
            axes[row, col].set_title(f'{model_name} - {metric_name}')
            axes[row, col].set_xlabel('Epochs')
            axes[row, col].set_ylabel(metric_name)
            axes[row, col].legend()

    plt.tight_layout()
    plt.show()
```

```python
histories = {
    'model_1': history_1,
    'model_2': history_2,
    'model_3': history_3
}

# Метрики, которые вы хотите визуализировать
metric_names = ['mae', 'loss']

# Вызов функции для визуализации
plot_all_metrics(histories, metric_names)
```




```python
!pip install keras-tuner --upgrade
```

```
Collecting keras-tuner
  Downloading keras_tuner-1.4.7-py3-none-any.whl (129 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 129.1/129.1 kB 2.7 MB/s eta 0:00:00
Requirement already satisfied: keras in /usr/local/lib/python3.10/dist-packages (from keras-tuner) (2.15.0)
Requirement already satisfied: packaging in /usr/local/lib/python3.10/dist-packages (from keras-tuner) (24.0)
Requirement already satisfied: requests in /usr/local/lib/python3.10/dist-packages (from keras-tuner) (2.31.0)
Collecting kt-legacy (from keras-tuner)
  Downloading kt_legacy-1.0.5-py3-none-any.whl (9.6 kB)
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.10/dist-packages (from requests->keras-tuner) (3.:
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests->keras-tuner) (3.7)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.10/dist-packages (from requests->keras-tuner) (2.0.7)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.10/dist-packages (from requests->keras-tuner) (2024.6.2
Installing collected packages: kt-legacy, keras-tuner
Successfully installed keras-tuner-1.4.7 kt-legacy-1.0.5
```

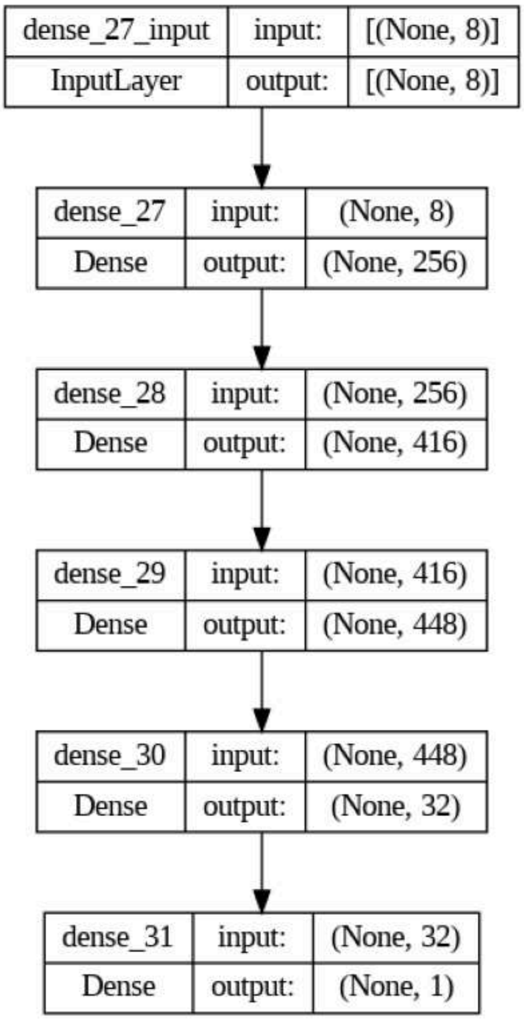
```
import kerastuner as kt
from keras.models import Sequential
from keras.layers import Dense
from sklearn.metrics import mean_squared_error, mean_absolute_error, r2_score

def build_model(hp):
    model = Sequential()
    model.add(Dense(units=hp.Int('units', min_value=32, max_value=512, step=32),
                    activation=hp.Choice('activation', values=['relu', 'tanh', 'sigmoid']),
                    input_dim=X_train.shape[1]))
    for i in range(hp.Int('num_layers', 1, 3)):
        model.add(Dense(units=hp.Int(f'units_{i}', min_value=32, max_value=512, step=32),
                        activation=hp.Choice(f'activation_{i}', values=['relu', 'tanh', 'sigmoid'])))
    model.add(Dense(1, activation='linear'))
    model.compile(
        optimizer=hp.Choice('optimizer', values=['adam', 'sgd', 'rmsprop']),
        loss='mean_squared_error',
        metrics=['mae']
    )
    return model

tuner = kt.Hyperband(
    build_model,
    objective='val_mae',
    max_epochs=10,
    hyperband_iterations=2,
    directory='my_dir',
    project_name='keras_tuner_demo'
)

# Поиск гиперпараметров
tuner.search(X_train, y_train, epochs=50, validation_split=0.2, verbose=1)

# Получение оптимальных гиперпараметров
best_hps = tuner.get_best_hyperparameters(num_trials=1)[0]
print(f"Лучшие гиперпараметры: {best_hps.values}")
```

```
Reloading Tuner from my_dir/keras_tuner_demo/tuner0.json
Лучшие гиперпараметры: {'units': 256, 'activation': 'tanh', 'num_layers': 3, 'units_0': 416, 'activation_0': 'tanh', 'optimizer': 'r
```

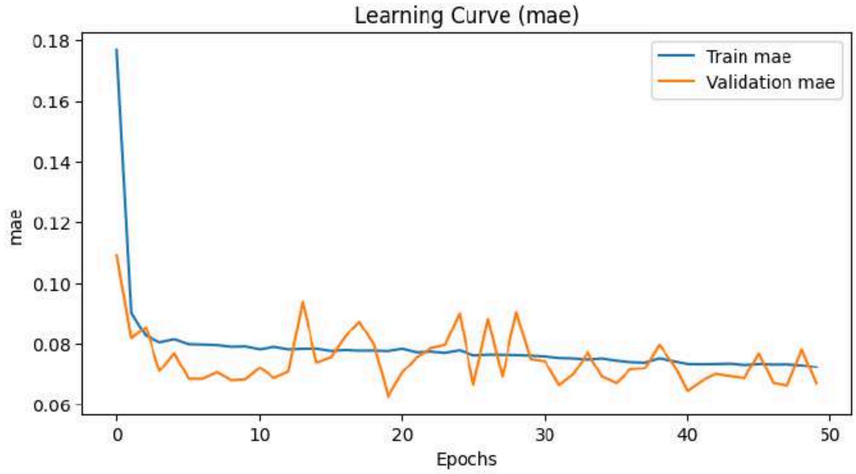
```
# Обучение модели с оптимальными гиперпараметрами
model = tuner.hypermodel.build(best_hps)
history = model.fit(X_train, y_train, epochs=50, validation_split=0.2, verbose=0)

# Оценка лучшей модели
eval_result = model.evaluate(X_test, y_test)
print("[test loss, test mae]:", eval_result)
```

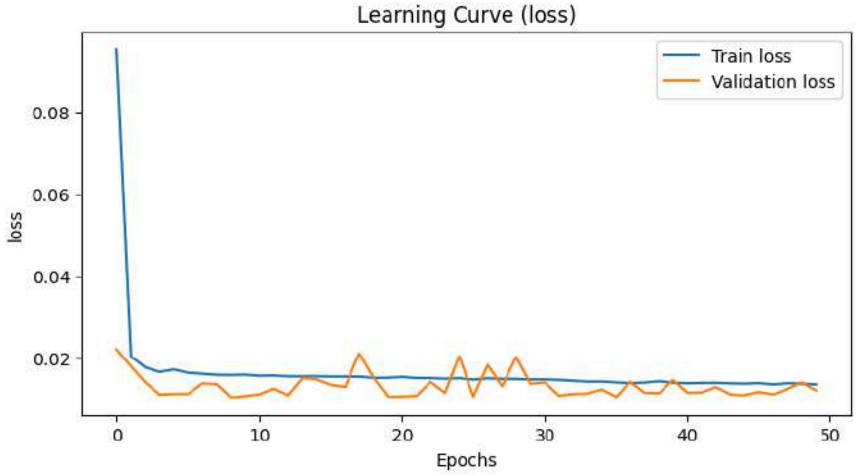
```
93/93 [==============================] - 0s 3ms/step - loss: 0.0156 - mae: 0.0764
[test loss, test mae]: [0.015587517991662025, 0.0763791874051094]
```

```
# Сохранение визуализации архитектуры модели в файл
plot_model(model, to_file='model_best.png', show_shapes=True, show_layer_names=True)

# Отображение изображения архитектуры модели
img = mpimg.imread('model_best.png')
plt.figure(figsize=(10, 10))
plt.imshow(img)
plt.axis('off')  # Скрыть оси
plt.show()
```




```python
import matplotlib.pyplot as plt

def plot_learning_curve(history, metric):
    plt.figure(figsize=(8, 4))
    plt.plot(history.history[metric], label=f'Train {metric}')
    plt.plot(history.history[f'val_{metric}'], label=f'Validation {metric}')
    plt.title(f'Learning Curve ({metric})')
    plt.xlabel('Epochs')
    plt.ylabel(metric)
    plt.legend()
    plt.show()


plot_learning_curve(history, 'mae')
plot_learning_curve(history, 'loss')


```





2) Задача классификации с помощью нейронных сетей

```
from keras.models import Sequential
from keras.layers import Dense, Dropout
from keras.optimizers import Adam
```

```
X_train = train[["tBodyAcc-max()-X","tBodyAccMag-mean()","tBodyGyroJerk-mad()-X","tGravityAcc-min()-X","fBodyAcc-bandsEnergy()-1,8.2","angle(X,
X_test = test[["tBodyAcc-max()-X","tBodyAccMag-mean()","tBodyGyroJerk-mad()-X","tGravityAcc-min()-X","fBodyAcc-bandsEnergy()-1,8.2","angle(X,gr

y_train = train["Activity"]
y_test = test["Activity"]
```

```
from sklearn.preprocessing import LabelEncoder
from keras.utils import to_categorical
# Создание экземпляра LabelEncoder
label_encoder = LabelEncoder()

# Обучение энкодера и преобразование меток
y_train_encoded = label_encoder.fit_transform(y_train)
y_test_encoded = label_encoder.transform(y_test)

# Теперь преобразование числовых меток в категориальный формат
y_train_categorical = to_categorical(y_train_encoded)
y_test_categorical = to_categorical(y_test_encoded)

```

```
# Архитектура 1: Простая полносвязная сеть
model_1 = Sequential([
    Dense(64, input_shape=(X_train.shape[1],), activation='relu'),
    Dense(64, activation='relu'),
    Dense(y_train_categorical.shape[1], activation='softmax')
])
model_1.compile(optimizer=Adam(lr=0.001), loss='categorical_crossentropy', metrics=['accuracy'])
history_1 = model_1.fit(X_train, y_train_categorical, epochs=30, batch_size=32, validation_split=0.2)
```

```
WARNING:absl:`lr` is deprecated in Keras optimizer, please use `learning_rate` or use the legacy optimizer, e.g.,tf.keras.optimi
Epoch 1/30
184/184 [==============================] - 4s 11ms/step - loss: 0.8929 - accuracy: 0.6854 - val_loss: 0.4422 - val_accuracy: 0.88
Epoch 2/30
184/184 [==============================] - 2s 11ms/step - loss: 0.4231 - accuracy: 0.8340 - val_loss: 0.3305 - val_accuracy: 0.90
Epoch 3/30
184/184 [==============================] - 2s 9ms/step - loss: 0.3318 - accuracy: 0.8594 - val_loss: 0.3382 - val_accuracy: 0.86
Epoch 4/30
184/184 [==============================] - 1s 5ms/step - loss: 0.2896 - accuracy: 0.8781 - val_loss: 0.3191 - val_accuracy: 0.88
Epoch 5/30
184/184 [==============================] - 1s 5ms/step - loss: 0.2664 - accuracy: 0.8888 - val_loss: 0.3359 - val_accuracy: 0.88
Epoch 6/30
184/184 [==============================] - 1s 5ms/step - loss: 0.2545 - accuracy: 0.8896 - val_loss: 0.3247 - val_accuracy: 0.88
Epoch 7/30
184/184 [==============================] - 1s 5ms/step - loss: 0.2472 - accuracy: 0.8953 - val_loss: 0.3153 - val_accuracy: 0.89
Epoch 8/30
184/184 [==============================] - 1s 5ms/step - loss: 0.2383 - accuracy: 0.8956 - val_loss: 0.3185 - val_accuracy: 0.88
Epoch 9/30
184/184 [==============================] - 1s 5ms/step - loss: 0.2316 - accuracy: 0.9004 - val_loss: 0.3167 - val_accuracy: 0.88
Epoch 10/30
184/184 [==============================] - 0s 3ms/step - loss: 0.2278 - accuracy: 0.9022 - val_loss: 0.3184 - val_accuracy: 0.89
Epoch 11/30
184/184 [==============================] - 0s 3ms/step - loss: 0.2230 - accuracy: 0.9036 - val_loss: 0.3088 - val_accuracy: 0.89
Epoch 12/30
184/184 [==============================] - 0s 2ms/step - loss: 0.2177 - accuracy: 0.9075 - val_loss: 0.3090 - val_accuracy: 0.88
Epoch 13/30
184/184 [==============================] - 1s 3ms/step - loss: 0.2139 - accuracy: 0.9072 - val_loss: 0.3034 - val_accuracy: 0.88
Epoch 14/30
184/184 [==============================] - 0s 3ms/step - loss: 0.2116 - accuracy: 0.9112 - val_loss: 0.3078 - val_accuracy: 0.89
Epoch 15/30
184/184 [==============================] - 1s 3ms/step - loss: 0.2107 - accuracy: 0.9099 - val_loss: 0.3263 - val_accuracy: 0.87
Epoch 16/30
184/184 [==============================] - 1s 3ms/step - loss: 0.2047 - accuracy: 0.9104 - val_loss: 0.3100 - val_accuracy: 0.89
Epoch 17/30
184/184 [==============================] - 1s 3ms/step - loss: 0.2016 - accuracy: 0.9145 - val_loss: 0.2991 - val_accuracy: 0.89
Epoch 18/30
184/184 [==============================] - 1s 3ms/step - loss: 0.1988 - accuracy: 0.9174 - val_loss: 0.2957 - val_accuracy: 0.89
Epoch 19/30
184/184 [==============================] - 0s 3ms/step - loss: 0.1987 - accuracy: 0.9158 - val_loss: 0.2897 - val_accuracy: 0.90
Epoch 20/30
184/184 [==============================] - 1s 3ms/step - loss: 0.1962 - accuracy: 0.9160 - val_loss: 0.3031 - val_accuracy: 0.89
Epoch 21/30
184/184 [==============================] - 1s 3ms/step - loss: 0.1934 - accuracy: 0.9186 - val_loss: 0.3005 - val_accuracy: 0.89
Epoch 22/30
184/184 [==============================] - 1s 3ms/step - loss: 0.1902 - accuracy: 0.9197 - val_loss: 0.2918 - val_accuracy: 0.89
Epoch 23/30
184/184 [==============================] - 1s 3ms/step - loss: 0.1884 - accuracy: 0.9175 - val_loss: 0.3076 - val_accuracy: 0.89
Epoch 24/30
184/184 [==============================] - 0s 3ms/step - loss: 0.1886 - accuracy: 0.9180 - val_loss: 0.3022 - val_accuracy: 0.89
Epoch 25/30
184/184 [==============================] - 0s 3ms/step - loss: 0.1857 - accuracy: 0.9214 - val_loss: 0.3179 - val_accuracy: 0.88
Epoch 26/30
184/184 [==============================] - 0s 3ms/step - loss: 0.1877 - accuracy: 0.9203 - val_loss: 0.2945 - val_accuracy: 0.89
Epoch 27/30
184/184 [==============================] - 0s 3ms/step - loss: 0.1869 - accuracy: 0.9199 - val_loss: 0.2899 - val_accuracy: 0.89
Epoch 28/30
184/184 [==============================] - 1s 4ms/step - loss: 0.1852 - accuracy: 0.9174 - val_loss: 0.2761 - val_accuracy: 0.90
```

```python
# Архитектура 2: Полносвязная сеть с Dropout
model_2 = Sequential([
    Dense(128, input_shape=(X_train.shape[1],), activation='relu'),
    Dropout(0.5),
    Dense(128, activation='relu'),
    Dropout(0.5),
    Dense(y_train_categorical.shape[1], activation='softmax')
])
model_2.compile(optimizer=Adam(lr=0.0005), loss='categorical_crossentropy', metrics=['accuracy'])
history_2 = model_2.fit(X_train, y_train_categorical, epochs=30, batch_size=64, validation_split=0.2)

```

```
WARNING:absl:`lr` is deprecated in Keras optimizer, please use `learning_rate` or use the legacy optimizer, e.g.,tf.keras.optimi
Epoch 1/30
92/92 [==============================] - 1s 6ms/step - loss: 1.1251 - accuracy: 0.5322 - val_loss: 0.5898 - val_accuracy: 0.8736
Epoch 2/30
92/92 [==============================] - 0s 4ms/step - loss: 0.6755 - accuracy: 0.6970 - val_loss: 0.4415 - val_accuracy: 0.8804
Epoch 3/30
92/92 [==============================] - 0s 4ms/step - loss: 0.5533 - accuracy: 0.7613 - val_loss: 0.3627 - val_accuracy: 0.9028
Epoch 4/30
92/92 [==============================] - 0s 5ms/step - loss: 0.4909 - accuracy: 0.7909 - val_loss: 0.3336 - val_accuracy: 0.8939
Epoch 5/30
92/92 [==============================] - 0s 4ms/step - loss: 0.4455 - accuracy: 0.8121 - val_loss: 0.3232 - val_accuracy: 0.8865
Epoch 6/30
92/92 [==============================] - 0s 4ms/step - loss: 0.4025 - accuracy: 0.8332 - val_loss: 0.3191 - val_accuracy: 0.8810
Epoch 7/30
92/92 [==============================] - 0s 4ms/step - loss: 0.3779 - accuracy: 0.8371 - val_loss: 0.3087 - val_accuracy: 0.8804
Epoch 8/30
92/92 [==============================] - 0s 4ms/step - loss: 0.3557 - accuracy: 0.8556 - val_loss: 0.3370 - val_accuracy: 0.8729
Epoch 9/30
```

```
92/92 [==============================] - 0s 4ms/step - loss: 0.3426 - accuracy: 0.8643 - val_loss: 0.3089 - val_accuracy: 0.8817
Epoch 10/30
92/92 [==============================] - 0s 4ms/step - loss: 0.3292 - accuracy: 0.8711 - val_loss: 0.3077 - val_accuracy: 0.8878
Epoch 11/30
92/92 [==============================] - 0s 4ms/step - loss: 0.3189 - accuracy: 0.8723 - val_loss: 0.3123 - val_accuracy: 0.8919
Epoch 12/30
92/92 [==============================] - 0s 4ms/step - loss: 0.3126 - accuracy: 0.8742 - val_loss: 0.3118 - val_accuracy: 0.8844
Epoch 13/30
92/92 [==============================] - 0s 3ms/step - loss: 0.3071 - accuracy: 0.8737 - val_loss: 0.3151 - val_accuracy: 0.8892
Epoch 14/30
92/92 [==============================] - 0s 4ms/step - loss: 0.3037 - accuracy: 0.8810 - val_loss: 0.3070 - val_accuracy: 0.8926
Epoch 15/30
92/92 [==============================] - 1s 6ms/step - loss: 0.2971 - accuracy: 0.8832 - val_loss: 0.3053 - val_accuracy: 0.8878
Epoch 16/30
92/92 [==============================] - 0s 4ms/step - loss: 0.2837 - accuracy: 0.8854 - val_loss: 0.3039 - val_accuracy: 0.8858
Epoch 17/30
92/92 [==============================] - 0s 4ms/step - loss: 0.2772 - accuracy: 0.8885 - val_loss: 0.3129 - val_accuracy: 0.8919
Epoch 18/30
92/92 [==============================] - 0s 4ms/step - loss: 0.2741 - accuracy: 0.8876 - val_loss: 0.3059 - val_accuracy: 0.8926
Epoch 19/30
92/92 [==============================] - 0s 4ms/step - loss: 0.2695 - accuracy: 0.8905 - val_loss: 0.3118 - val_accuracy: 0.8926
Epoch 20/30
92/92 [==============================] - 0s 4ms/step - loss: 0.2602 - accuracy: 0.8941 - val_loss: 0.2993 - val_accuracy: 0.8939
Epoch 21/30
92/92 [==============================] - 1s 6ms/step - loss: 0.2574 - accuracy: 0.8953 - val_loss: 0.3097 - val_accuracy: 0.8831
Epoch 22/30
92/92 [==============================] - 1s 7ms/step - loss: 0.2575 - accuracy: 0.8978 - val_loss: 0.3013 - val_accuracy: 0.8899
Epoch 23/30
92/92 [==============================] - 1s 7ms/step - loss: 0.2616 - accuracy: 0.8961 - val_loss: 0.2933 - val_accuracy: 0.8933
Epoch 24/30
92/92 [==============================] - 1s 8ms/step - loss: 0.2499 - accuracy: 0.8978 - val_loss: 0.3005 - val_accuracy: 0.8933
Epoch 25/30
92/92 [==============================] - 1s 6ms/step - loss: 0.2507 - accuracy: 0.8995 - val_loss: 0.2966 - val_accuracy: 0.8939
Epoch 26/30
92/92 [==============================] - 1s 7ms/step - loss: 0.2473 - accuracy: 0.9019 - val_loss: 0.3174 - val_accuracy: 0.8906
Epoch 27/30
92/92 [==============================] - 1s 7ms/step - loss: 0.2417 - accuracy: 0.9034 - val_loss: 0.3135 - val_accuracy: 0.8946
Epoch 28/30
92/92 [==============================] - 1s 6ms/step - loss: 0.2410 - accuracy: 0.9012 - val_loss: 0.3032 - val_accuracy: 0.8939
```

```python
# Архитектура 3: Глубокая полносвязная сеть
model_3 = Sequential([
    Dense(256, input_shape=(X_train.shape[1],), activation='relu'),
    Dense(256, activation='relu'),
    Dense(256, activation='relu'),
    Dense(256, activation='relu'),
    Dense(256, activation='relu'),
    Dense(256, activation='relu'),
    Dense(y_train_categorical.shape[1], activation='softmax')
])
model_3.compile(optimizer=Adam(lr=0.0001), loss='categorical_crossentropy', metrics=['accuracy'])
history_3 = model_3.fit(X_train, y_train_categorical, epochs=30, batch_size=128, validation_split=0.2)
```

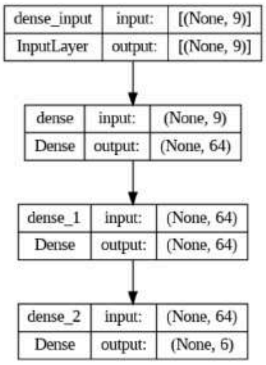
```
WARNING:absl:`lr` is deprecated in Keras optimizer, please use `learning_rate` or use the legacy optimizer, e.g.,tf.keras.optimiz
Epoch 1/30
46/46 [==============================] - 2s 21ms/step - loss: 0.7686 - accuracy: 0.6910 - val_loss: 0.3338 - val_accuracy: 0.8892
Epoch 2/30
46/46 [==============================] - 1s 16ms/step - loss: 0.3431 - accuracy: 0.8485 - val_loss: 0.4094 - val_accuracy: 0.8559
Epoch 3/30
46/46 [==============================] - 1s 16ms/step - loss: 0.2748 - accuracy: 0.8845 - val_loss: 0.3307 - val_accuracy: 0.8851
Epoch 4/30
46/46 [==============================] - 1s 14ms/step - loss: 0.2477 - accuracy: 0.8908 - val_loss: 0.3162 - val_accuracy: 0.8858
Epoch 5/30
46/46 [==============================] - 1s 16ms/step - loss: 0.2247 - accuracy: 0.9078 - val_loss: 0.2970 - val_accuracy: 0.8980
Epoch 6/30
46/46 [==============================] - 1s 16ms/step - loss: 0.2114 - accuracy: 0.9114 - val_loss: 0.3116 - val_accuracy: 0.8824
Epoch 7/30
46/46 [==============================] - 1s 21ms/step - loss: 0.2126 - accuracy: 0.9097 - val_loss: 0.3118 - val_accuracy: 0.8783
Epoch 8/30
46/46 [==============================] - 1s 26ms/step - loss: 0.2236 - accuracy: 0.9061 - val_loss: 0.3125 - val_accuracy: 0.8776
Epoch 9/30
46/46 [==============================] - 1s 25ms/step - loss: 0.1990 - accuracy: 0.9220 - val_loss: 0.2955 - val_accuracy: 0.8899
Epoch 10/30
46/46 [==============================] - 1s 27ms/step - loss: 0.1770 - accuracy: 0.9243 - val_loss: 0.3117 - val_accuracy: 0.8865
Epoch 11/30
46/46 [==============================] - 1s 27ms/step - loss: 0.1768 - accuracy: 0.9277 - val_loss: 0.3025 - val_accuracy: 0.8919
Epoch 12/30
46/46 [==============================] - 1s 29ms/step - loss: 0.1775 - accuracy: 0.9265 - val_loss: 0.3005 - val_accuracy: 0.8926
Epoch 13/30
46/46 [==============================] - 1s 16ms/step - loss: 0.1642 - accuracy: 0.9308 - val_loss: 0.3627 - val_accuracy: 0.8790
Epoch 14/30
46/46 [==============================] - 1s 15ms/step - loss: 0.1594 - accuracy: 0.9337 - val_loss: 0.3481 - val_accuracy: 0.8872
Epoch 15/30
46/46 [==============================] - 1s 15ms/step - loss: 0.1774 - accuracy: 0.9245 - val_loss: 0.3728 - val_accuracy: 0.8804
Epoch 16/30
46/46 [==============================] - 1s 16ms/step - loss: 0.1583 - accuracy: 0.9323 - val_loss: 0.3657 - val_accuracy: 0.8790
Epoch 17/30
```

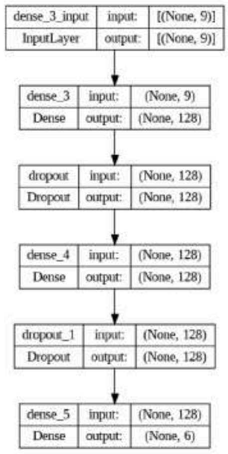
```
46/46 [==============================] - 1s 16ms/step - loss: 0.1470 - accuracy: 0.9347 - val_loss: 0.4045 - val_accuracy: 0.874
Epoch 18/30
46/46 [==============================] - 1s 15ms/step - loss: 0.1470 - accuracy: 0.9350 - val_loss: 0.3850 - val_accuracy: 0.890
Epoch 19/30
46/46 [==============================] - 1s 15ms/step - loss: 0.1419 - accuracy: 0.9373 - val_loss: 0.3895 - val_accuracy: 0.863
Epoch 20/30
46/46 [==============================] - 1s 16ms/step - loss: 0.1384 - accuracy: 0.9356 - val_loss: 0.3401 - val_accuracy: 0.877
Epoch 21/30
46/46 [==============================] - 1s 20ms/step - loss: 0.1399 - accuracy: 0.9405 - val_loss: 0.3775 - val_accuracy: 0.891
Epoch 22/30
46/46 [==============================] - 1s 26ms/step - loss: 0.1274 - accuracy: 0.9410 - val_loss: 0.3968 - val_accuracy: 0.883
Epoch 23/30
46/46 [==============================] - 1s 24ms/step - loss: 0.1222 - accuracy: 0.9444 - val_loss: 0.3850 - val_accuracy: 0.886
Epoch 24/30
46/46 [==============================] - 1s 27ms/step - loss: 0.1287 - accuracy: 0.9420 - val_loss: 0.4216 - val_accuracy: 0.885
Epoch 25/30
46/46 [==============================] - 1s 32ms/step - loss: 0.1212 - accuracy: 0.9442 - val_loss: 0.4838 - val_accuracy: 0.864
Epoch 26/30
46/46 [==============================] - 1s 32ms/step - loss: 0.1222 - accuracy: 0.9442 - val_loss: 0.4150 - val_accuracy: 0.871
Epoch 27/30
46/46 [==============================] - 1s 32ms/step - loss: 0.1189 - accuracy: 0.9480 - val_loss: 0.3874 - val_accuracy: 0.870
Epoch 28/30
```

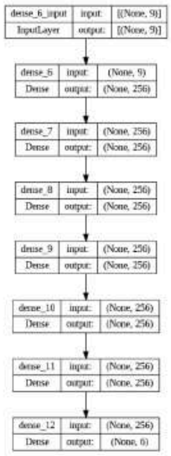
```python
# Оценка моделей
score_1 = model_1.evaluate(X_test, y_test_categorical, verbose=1)
score_2 = model_2.evaluate(X_test, y_test_categorical, verbose=1)
score_3 = model_3.evaluate(X_test, y_test_categorical, verbose=1)

print(f'Модель 1 - Точность: {score_1[1]:.4f}')
print(f'Модель 2 - Точность: {score_2[1]:.4f}')
print(f'Модель 3 - Точность: {score_3[1]:.4f}')
```

```
93/93 [==============================] - 0s 3ms/step - loss: 0.5275 - accuracy: 0.8208
93/93 [==============================] - 0s 3ms/step - loss: 0.4783 - accuracy: 0.8347
93/93 [==============================] - 1s 6ms/step - loss: 1.2838 - accuracy: 0.8056
Модель 1 - Точность: 0.8208
Модель 2 - Точность: 0.8347
Модель 3 - Точность: 0.8056
```

```python
from tensorflow.keras.utils import plot_model
from IPython.display import Image
import matplotlib.image as mpimg

# Сохранение визуализаций архитектур моделей в файлы
plot_model(model_1, to_file='model_1_cl.png', show_shapes=True, show_layer_names=True)
plot_model(model_2, to_file='model_2_cl.png', show_shapes=True, show_layer_names=True)
plot_model(model_3, to_file='model_3_cl.png', show_shapes=True, show_layer_names=True)

# Отображение изображений архитектур моделей на одном plot
fig, axs = plt.subplots(1, 3, figsize=(20, 10))

# Отображение модели 1
img_1 = mpimg.imread('model_1_cl.png')
axs[0].imshow(img_1)
axs[0].axis('off')  # Скрыть оси

# Отображение модели 2
img_2 = mpimg.imread('model_2_cl.png')
axs[1].imshow(img_2)
axs[1].axis('off')

# Отображение модели 3
img_3 = mpimg.imread('model_3_cl.png')
axs[2].imshow(img_3)
axs[2].axis('off')

plt.show()


```

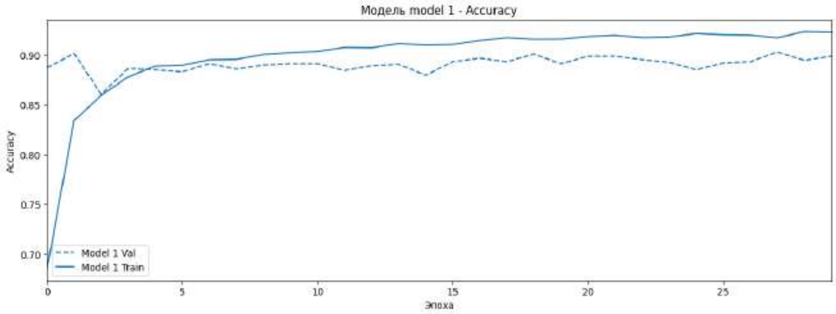


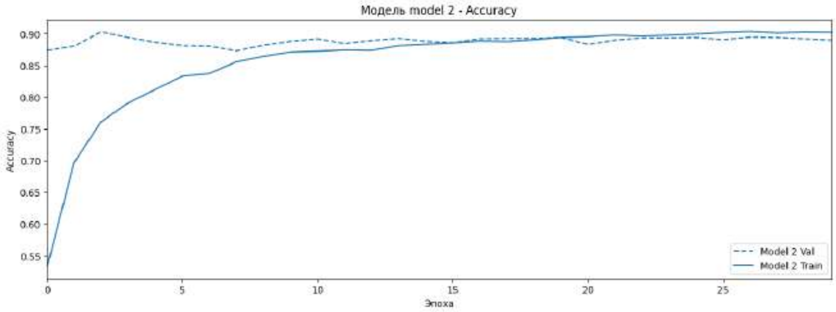


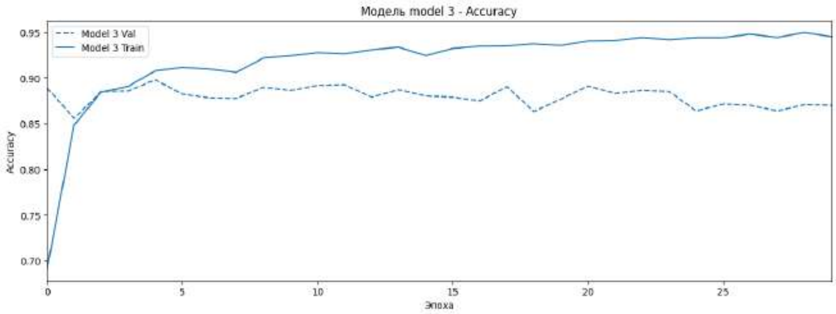


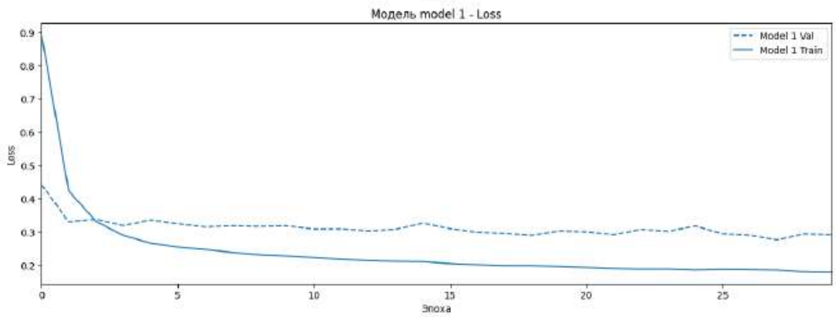

```python
def plot_history(history, name, key='accuracy'):
    plt.figure(figsize=(15, 5))

    val = plt.plot(history.epoch, history.history['val_'+key],
                   '--', label=name.title()+' Val')
    plt.plot(history.epoch, history.history[key], color=val[0].get_color(),
             label=name.title()+' Train')

    plt.title(f'Модель {name} - {key.replace("_", " ").title()}')
    plt.xlabel('Эпоха')
    plt.ylabel(key.replace('_', ' ').title())
    plt.legend()
    plt.xlim([0, max(history.epoch)])
    plt.show()
```

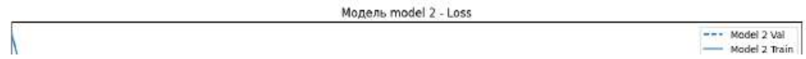
```python
plot_history(history_1, 'model 1', key='accuracy')
plot_history(history_2, 'model 2', key='accuracy')
plot_history(history_3, 'model 3', key='accuracy')

# Построение графика потерь для каждой модели
plot_history(history_1, 'model 1', key='loss')
plot_history(history_2, 'model 2', key='loss')
plot_history(history_3, 'model 3', key='loss')
```












```
!pip install keras-tuner --upgrade
```

```
Collecting keras-tuner
  Downloading keras_tuner-1.4.7-py3-none-any.whl (129 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 129.1/129.1 kB 4.2 MB/s eta 0:00:00
Requirement already satisfied: keras in /usr/local/lib/python3.10/dist-packages (from keras-tuner) (2.15.0)
Requirement already satisfied: packaging in /usr/local/lib/python3.10/dist-packages (from keras-tuner) (24.1)
Requirement already satisfied: requests in /usr/local/lib/python3.10/dist-packages (from keras-tuner) (2.31.0)
Collecting kt-legacy (from keras-tuner)
  Downloading kt_legacy-1.0.5-py3-none-any.whl (9.6 kB)
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.10/dist-packages (from requests->keras-tuner) (3.:
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests->keras-tuner) (3.7)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.10/dist-packages (from requests->keras-tuner) (2.0.7)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.10/dist-packages (from requests->keras-tuner) (2024.6.2
Installing collected packages: kt-legacy, keras-tuner
Successfully installed keras-tuner-1.4.7 kt-legacy-1.0.5
```

```
from kerastuner import RandomSearch
from kerastuner.engine.hyperparameters import HyperParameters
import tensorflow as tf
from tensorflow.keras import Sequential
from keras.layers import Dense, Dropout
from keras.optimizers import Adam
```

```
<ipython-input-21-b0a47e0e0420>:1: DeprecationWarning: `import kerastuner` is deprecated, please use `import keras_tuner`.
  from kerastuner import RandomSearch
```

```python
# Функция создания модели с гиперпараметрами
def build_model(hp):
    model = Sequential()
    model.add(Dense(hp.Int('input_units', min_value=32, max_value=256, step=32),
                    input_shape=(X_train.shape[1],), activation='relu'))
    model.add(Dropout(hp.Float('dropout_1', min_value=0.0, max_value=0.5, default=0.25, step=0.05)))
    model.add(Dense(hp.Int('dense_1_units', min_value=32, max_value=256, step=32), activation='relu'))
    model.add(Dropout(hp.Float('dropout_2', min_value=0.0, max_value=0.5, default=0.25, step=0.05)))
    model.add(Dense(y_train_categorical.shape[1], activation='softmax'))

    model.compile(optimizer=Adam(hp.Choice('learning_rate', values=[1e-2, 1e-3, 1e-4])),
                  loss='categorical_crossentropy',
                  metrics=['accuracy'])
    return model

# Создание объекта RandomSearch
tuner = RandomSearch(
    build_model,
    objective='val_accuracy',
    max_trials=5,  # Количество вариантов гиперпараметров для пробы
    executions_per_trial=3,  # Количество повторений каждого эксперимента
    directory='my_dir',  # Директория для сохранения логов
    project_name='hparam_tuning'
)
```

```python
# Запуск поиска
tuner.search(X_train, y_train_categorical,
             epochs=10,
             batch_size=64,
             validation_split=0.2)

# Получение наилучших гиперпараметров
best_hps = tuner.get_best_hyperparameters(num_trials=1)[0]
```

```
Trial 5 Complete [00h 00m 25s]
val_accuracy: 0.8991615573565165

Best val_accuracy So Far: 0.905733068784078
Total elapsed time: 00h 02m 40s
```

```python
# Загрузка лучшей модели
best_model = tuner.get_best_models(num_models=1)[0]
```

```python
# Получение значений гиперпараметров с проверкой на их наличие
epochs = best_hps.get('epochs') if 'epochs' in best_hps.values else 40
batch_size = best_hps.get('batch_size') if 'batch_size' in best_hps.values else 64

# Обучение модели с лучшими гиперпараметрами
history = best_model.fit(X_train, y_train_categorical,
                         epochs=epochs,
                         batch_size=batch_size,
                         validation_split=0.2)
```

```
Epoch 1/40
92/92 [==============================] - 2s 10ms/step - loss: 0.5372 - accuracy: 0.7856 - val_loss: 0.4287 - val_accuracy: 0.897
Epoch 2/40
92/92 [==============================] - 1s 7ms/step - loss: 0.5205 - accuracy: 0.7905 - val_loss: 0.4065 - val_accuracy: 0.9021
Epoch 3/40
92/92 [==============================] - 1s 7ms/step - loss: 0.4935 - accuracy: 0.7960 - val_loss: 0.3891 - val_accuracy: 0.9103
Epoch 4/40
92/92 [==============================] - 1s 7ms/step - loss: 0.4731 - accuracy: 0.8118 - val_loss: 0.3753 - val_accuracy: 0.9028
Epoch 5/40
92/92 [==============================] - 1s 7ms/step - loss: 0.4657 - accuracy: 0.8107 - val_loss: 0.3644 - val_accuracy: 0.9075
Epoch 6/40
92/92 [==============================] - 1s 8ms/step - loss: 0.4498 - accuracy: 0.8158 - val_loss: 0.3563 - val_accuracy: 0.8906
Epoch 7/40
92/92 [==============================] - 1s 8ms/step - loss: 0.4428 - accuracy: 0.8206 - val_loss: 0.3476 - val_accuracy: 0.9048
Epoch 8/40
92/92 [==============================] - 0s 4ms/step - loss: 0.4288 - accuracy: 0.8225 - val_loss: 0.3434 - val_accuracy: 0.8892
Epoch 9/40
92/92 [==============================] - 0s 4ms/step - loss: 0.4216 - accuracy: 0.8208 - val_loss: 0.3381 - val_accuracy: 0.8946
Epoch 10/40
92/92 [==============================] - 0s 4ms/step - loss: 0.4127 - accuracy: 0.8271 - val_loss: 0.3348 - val_accuracy: 0.8804
Epoch 11/40
92/92 [==============================] - 0s 5ms/step - loss: 0.3952 - accuracy: 0.8385 - val_loss: 0.3363 - val_accuracy: 0.8729
Epoch 12/40
92/92 [==============================] - 0s 4ms/step - loss: 0.3998 - accuracy: 0.8312 - val_loss: 0.3290 - val_accuracy: 0.8878
Epoch 13/40
```

```
92/92 [==============================] - 0s 4ms/step - loss: 0.3878 - accuracy: 0.8381 - val_loss: 0.3269 - val_accuracy: 0.8810
Epoch 14/40
92/92 [==============================] - 0s 4ms/step - loss: 0.3763 - accuracy: 0.8473 - val_loss: 0.3258 - val_accuracy: 0.8865
Epoch 15/40
92/92 [==============================] - 0s 4ms/step - loss: 0.3786 - accuracy: 0.8398 - val_loss: 0.3256 - val_accuracy: 0.8810
Epoch 16/40
92/92 [==============================] - 0s 4ms/step - loss: 0.3742 - accuracy: 0.8432 - val_loss: 0.3272 - val_accuracy: 0.8722
Epoch 17/40
92/92 [==============================] - 0s 4ms/step - loss: 0.3661 - accuracy: 0.8415 - val_loss: 0.3236 - val_accuracy: 0.8797
Epoch 18/40
92/92 [==============================] - 0s 4ms/step - loss: 0.3599 - accuracy: 0.8478 - val_loss: 0.3221 - val_accuracy: 0.8797
Epoch 19/40
92/92 [==============================] - 0s 5ms/step - loss: 0.3552 - accuracy: 0.8459 - val_loss: 0.3225 - val_accuracy: 0.8770
Epoch 20/40
92/92 [==============================] - 0s 4ms/step - loss: 0.3466 - accuracy: 0.8533 - val_loss: 0.3238 - val_accuracy: 0.8736
Epoch 21/40
92/92 [==============================] - 0s 5ms/step - loss: 0.3433 - accuracy: 0.8587 - val_loss: 0.3252 - val_accuracy: 0.8736
Epoch 22/40
92/92 [==============================] - 0s 4ms/step - loss: 0.3388 - accuracy: 0.8558 - val_loss: 0.3219 - val_accuracy: 0.8790
Epoch 23/40
92/92 [==============================] - 0s 4ms/step - loss: 0.3342 - accuracy: 0.8607 - val_loss: 0.3236 - val_accuracy: 0.8756
Epoch 24/40
92/92 [==============================] - 0s 4ms/step - loss: 0.3369 - accuracy: 0.8599 - val_loss: 0.3269 - val_accuracy: 0.8708
Epoch 25/40
92/92 [==============================] - 0s 4ms/step - loss: 0.3307 - accuracy: 0.8609 - val_loss: 0.3231 - val_accuracy: 0.8763
Epoch 26/40
92/92 [==============================] - 0s 5ms/step - loss: 0.3268 - accuracy: 0.8606 - val_loss: 0.3221 - val_accuracy: 0.8776
Epoch 27/40
92/92 [==============================] - 0s 4ms/step - loss: 0.3239 - accuracy: 0.8587 - val_loss: 0.3267 - val_accuracy: 0.8729
Epoch 28/40
92/92 [==============================] - 0s 4ms/step - loss: 0.3245 - accuracy: 0.8631 - val_loss: 0.3234 - val_accuracy: 0.8756
Epoch 29/40
```

```python
from sklearn.metrics import classification_report, confusion_matrix

# Оценка модели на тестовых данных
test_loss, test_accuracy = best_model.evaluate(X_test, y_test_categorical)
print(f"Тестовая потеря: {test_loss}")
print(f"Тестовая точность: {test_accuracy}")

```

```
93/93 [==============================] - 0s 2ms/step - loss: 0.4183 - accuracy: 0.8351
Тестовая потеря: 0.41826650500297546
Тестовая точность: 0.8350865244865417
```

```python
# Предсказания на тестовых данных
y_pred = best_model.predict(X_test)
y_pred_classes = np.argmax(y_pred, axis=1)
y_true = np.argmax(y_test_categorical, axis=1)

```

```
93/93 [==============================] - 0s 2ms/step
```

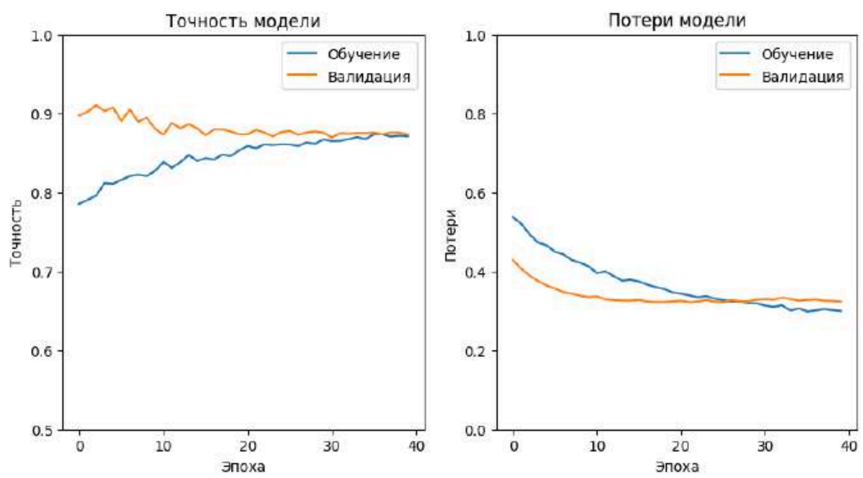
```python

# Вывод отчета о классификации
print(classification_report(y_true, y_pred_classes))
```

```
              precision    recall  f1-score   support

           0       1.00      0.99      1.00       537
           1       0.86      0.75      0.80       491
           2       0.79      0.89      0.84       532
           3       0.80      0.86      0.83       496
           4       0.81      0.75      0.78       420
           5       0.74      0.73      0.73       471

    accuracy                           0.84      2947
   macro avg       0.83      0.83      0.83      2947
weighted avg       0.84      0.84      0.83      2947
```

```python
# Вывод матрицы ошибок
print(confusion_matrix(y_true, y_pred_classes))
```

```
[[533   0   4   0   0   0]
 [  0 369 119   0   0   3]
 [  0  60 471   0   0   1]
 [  0   0   0 427  34  35]
 [  0   0   0  19 316  85]
 [  0   0   0  86  40 345]]
```

```python
# Установка размера фигуры для более детального просмотра
plt.figure(figsize=(10, 5))

# Построение графика точности
plt.subplot(1, 2, 1)
plt.plot(history.history['accuracy'], label='Обучение')
plt.plot(history.history['val_accuracy'], label='Валидация')
plt.title('Точность модели')
plt.xlabel('Эпоха')
plt.ylabel('Точность')
plt.legend()

# Установка пределов для оси Y, чтобы увидеть более мелкие изменения
plt.ylim(0.5, 1)  # Например, если вы хотите видеть изменения от 50% до 100%

# Построение графика потерь
plt.subplot(1, 2, 2)
plt.plot(history.history['loss'], label='Обучение')
plt.plot(history.history['val_loss'], label='Валидация')
plt.title('Потери модели')
plt.xlabel('Эпоха')
plt.ylabel('Потери')
plt.legend()

# Установка пределов для оси Y, чтобы увидеть более мелкие изменения
plt.ylim(0, 1)  # Например, если вы хотите видеть изменения от 0 до 1

plt.show()
```



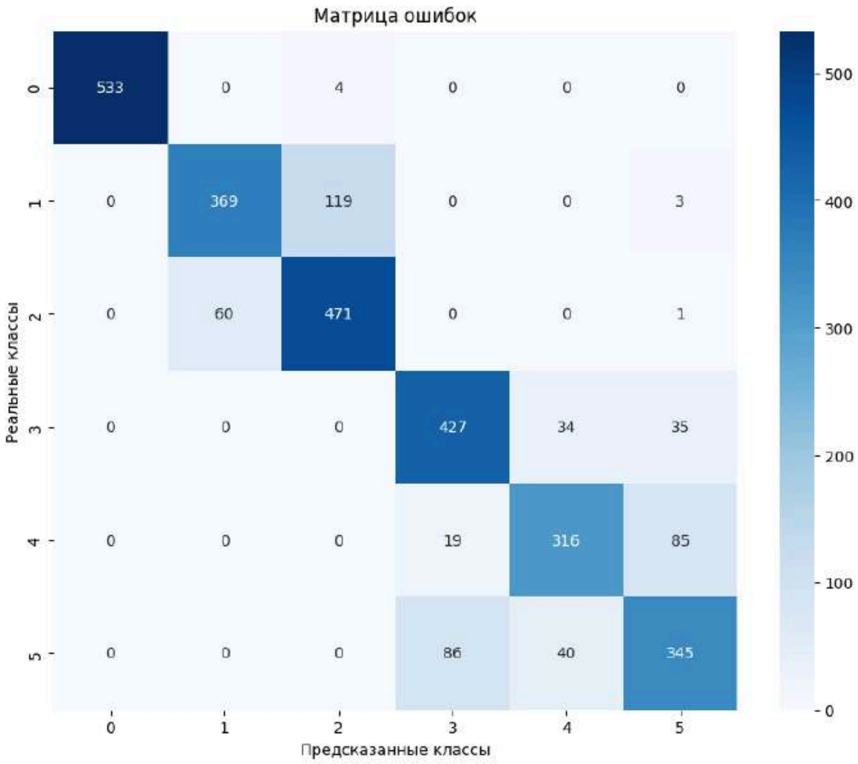

```python
import numpy as np
import matplotlib.pyplot as plt

# Предсказание классов для тестового набора данных
y_pred = best_model.predict(X_test)
y_pred_classes = np.argmax(y_pred, axis=1)

# Вывод реальных и предсказанных классов
for i in range(70, 90):
    print(f'Пример {i+1}: Реальный класс - {y_true[i]}, Предсказанный класс - {y_pred_classes[i]}')
```

```
93/93 [==============================] - 0s 3ms/step
Пример 71: Реальный класс - 0, Предсказанный класс - 0
Пример 72: Реальный класс - 0, Предсказанный класс - 0
Пример 73: Реальный класс - 0, Предсказанный класс - 0
Пример 74: Реальный класс - 0, Предсказанный класс - 0
Пример 75: Реальный класс - 0, Предсказанный класс - 0
Пример 76: Реальный класс - 0, Предсказанный класс - 0
Пример 77: Реальный класс - 0, Предсказанный класс - 0
Пример 78: Реальный класс - 0, Предсказанный класс - 0
Пример 79: Реальный класс - 0, Предсказанный класс - 0
Пример 80: Реальный класс - 3, Предсказанный класс - 3
Пример 81: Реальный класс - 3, Предсказанный класс - 3
Пример 82: Реальный класс - 3, Предсказанный класс - 3
Пример 83: Реальный класс - 3, Предсказанный класс - 3
Пример 84: Реальный класс - 3, Предсказанный класс - 3
Пример 85: Реальный класс - 3, Предсказанный класс - 3
```

```
Пример 86: Реальный класс - 3, Предсказанный класс - 3
Пример 87: Реальный класс - 3, Предсказанный класс - 3
Пример 88: Реальный класс - 3, Предсказанный класс - 3
Пример 89: Реальный класс - 3, Предсказанный класс - 3
Пример 90: Реальный класс - 3, Предсказанный класс - 3
```

```python
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.metrics import confusion_matrix

# Предсказания на тестовых данных
y_pred = best_model.predict(X_test)
y_pred_classes = np.argmax(y_pred, axis=1)
y_true = np.argmax(y_test_categorical, axis=1)

# Визуализация матрицы ошибок
plt.figure(figsize=(10, 8))
cm = confusion_matrix(y_true, y_pred_classes)
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.title('Матрица ошибок')
plt.xlabel('Предсказанные классы')
plt.ylabel('Реальные классы')
plt.show()


plt.show()

```

```
93/93 [==============================] - 0s 4ms/step
```




```

```

3) AutoKeras

3) Возьмите датасет или изображений, или видео, или текстов, или звуковых/речевых данных, которые связаны с вашим проектом и нужны для решения задач проекта или создания нового умного функционала продукта/сервиса проекта.

Проведите обработку взятых данных с помощью нейронных сетей (аналогично предыдущим пунктам).

Выполните п.3, используя AutoKeras.

*Если ваш проект связан с рекомендательными системами или обучением с подкреплением, то можно адаптировать/изменить п.3 для решения такой задачи.

```
import os
import numpy as np
import pandas as pd
import tensorflow as tf

from tensorflow import io
from tensorflow import data as tfd
from tensorflow import image as tfi
from tensorflow.keras.preprocessing.image import ImageDataGenerator

import plotly.express as px
import matplotlib.pyplot as plt
```

```
from google.colab import drive
drive.mount('/content/drive')

```

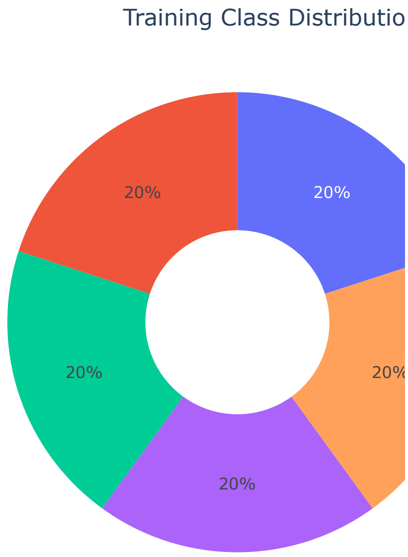
```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True).
```

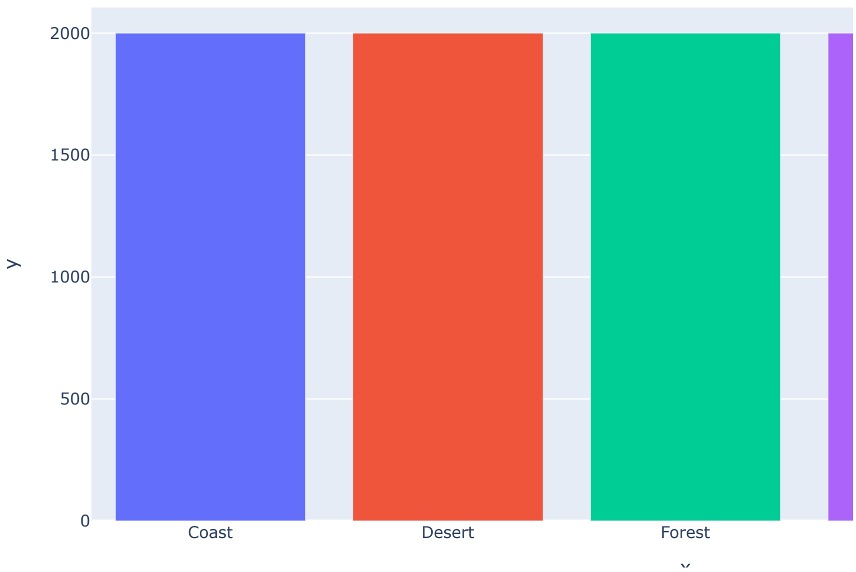
```
train_path = "/content/drive/MyDrive/landscape/Training Data/"
test_path = "/content/drive/MyDrive/landscape/Testing Data/"
valid_path = "/content/drive/MyDrive/landscape/Validation Data/"
```

```
# Class Names
class_names = sorted(os.listdir(train_path))
n_classes = len(class_names)

# Show
print(f"Number of Classes : {n_classes}\nClass names : {class_names}")
```

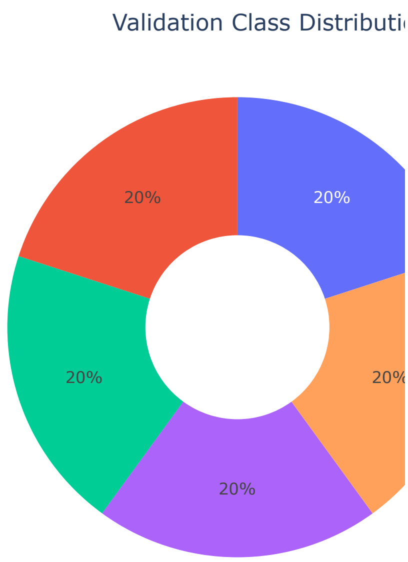
```
Number of Classes : 5
Class names : ['Coast', 'Desert', 'Forest', 'Glacier', 'Mountain']
```

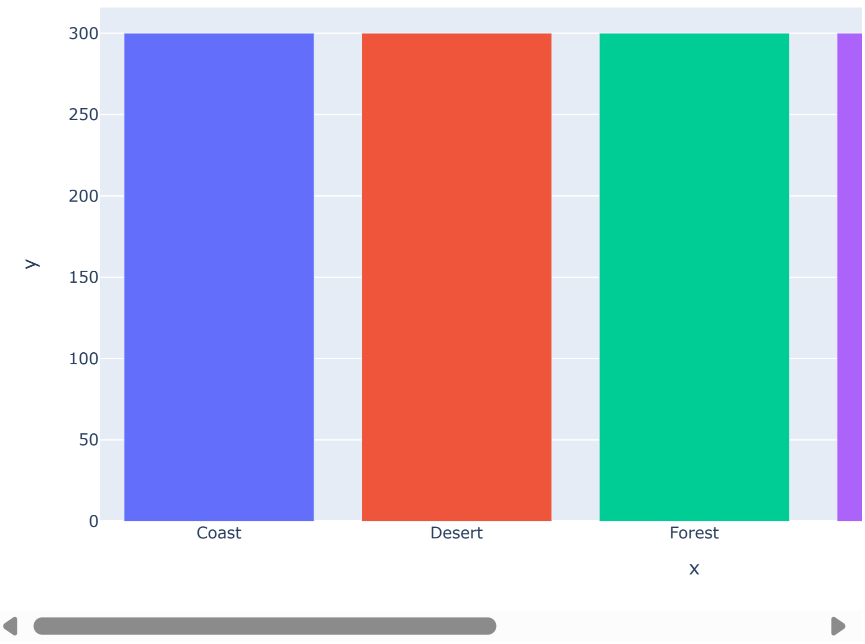
```
# Class Distribution
class_dis = [len(os.listdir(train_path + name)) for name in class_names]


# Visualize
fig = px.pie(names=class_names, values=class_dis, title="Training Class Distribution", hole=0.4)
fig.update_layout({'title':{'x':0.5}})
fig.show()

fig = px.bar(x=class_names, y=class_dis, color=class_names)
fig.show()
```



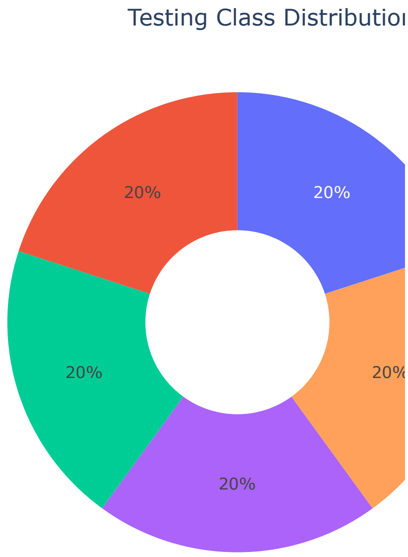


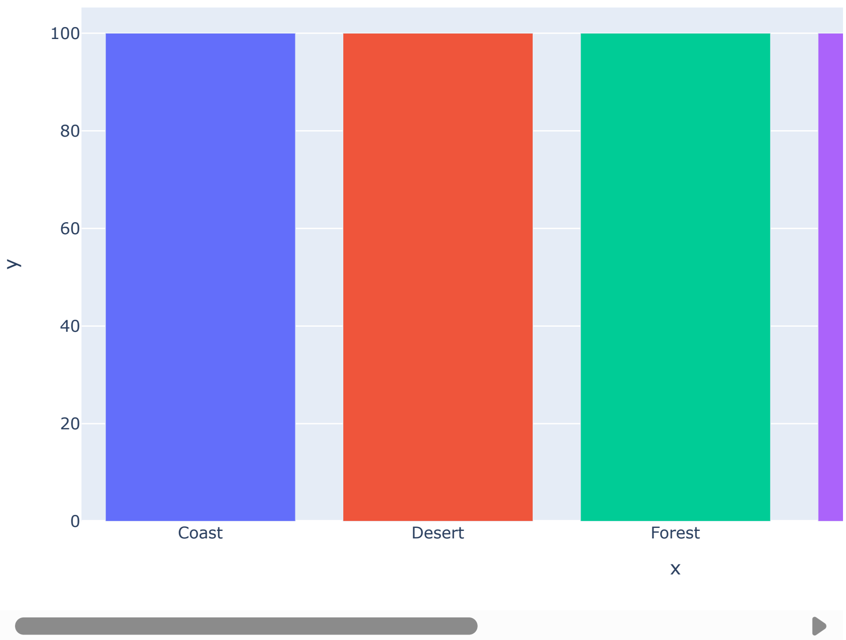

```
# Class Distribution
class_dis = [len(os.listdir(valid_path + name)) for name in class_names]


# Visualize
fig = px.pie(names=class_names, values=class_dis, title="Validation Class Distribution", hole=0.4)
fig.update_layout({'title':{'x':0.5}})
fig.show()

fig = px.bar(x=class_names, y=class_dis, color=class_names)
fig.show()
```






```
# Class Distribution
class_dis = [len(os.listdir(test_path + name)) for name in class_names]


# Visualize
fig = px.pie(names=class_names, values=class_dis, title="Testing Class Distribution", hole=0.4)
fig.update_layout({'title':{'x':0.5}})
fig.show()

fig = px.bar(x=class_names, y=class_dis, color=class_names)
fig.show()
```






```python
# List all TFRecords Paths
tfr_train = "/content/drive/MyDrive/landscape/TFrecords/Train/"
tfr_valid = "/content/drive/MyDrive/landscape/TFrecords/Valid/"
tfr_test = "/content/drive/MyDrive/landscape/TFrecords/Test/"
```

```python
print(f"Train TFRecords : {len(os.listdir(tfr_train))} = {len(os.listdir(tfr_train))//5} X 5")
print(f"Valid TFRecords : {len(os.listdir(tfr_valid))} = {len(os.listdir(tfr_valid))//5} X 5")
print(f"Test TFRecords : {len(os.listdir(tfr_test))} = {len(os.listdir(tfr_test))//5} X 5")
```

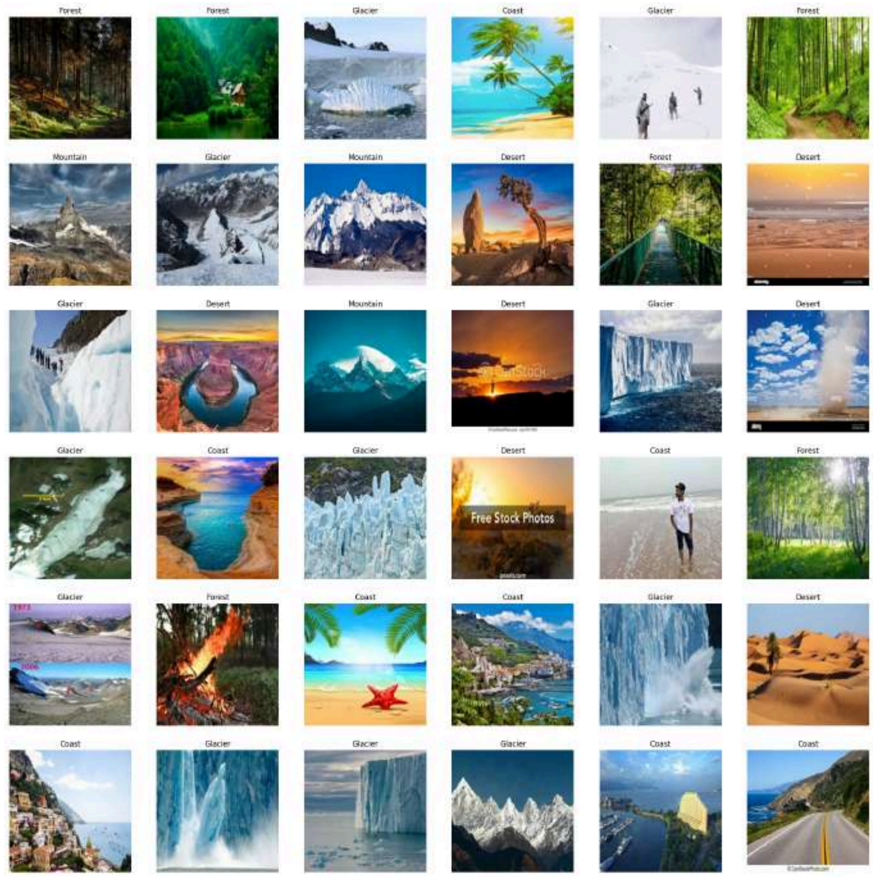
```
Train TFRecords : 10000 = 2000 X 5
Valid TFRecords : 1500 = 300 X 5
Test TFRecords : 500 = 100 X 5
```

```python
def decode_image(image):
    image = tfi.decode_jpeg(image, channels=3)
#     image = tfi.resize(image, (256,256))
    # Apply any augmentations here.
    image = tf.cast(image, tf.float32)
    image = image/255.
    return image

def decode_data(example):
    features = {
```

```
    features = {
        'image':io.FixedLenFeature([], tf.string),
        'label':io.FixedLenFeature([], tf.int64)
    }

    example = io.parse_single_example(example, features)
    image, label = example['image'], example['label']
    image = decode_image(image)
    return image, label

def load_data(file_dir, BATCH_SIZE=32, BUFFER=1000):
    AUTOTUNE = tfd.AUTOTUNE
    file_dir = file_dir + "*.tfrecord"
    files = tfd.Dataset.list_files(file_dir)
    data = tfd.TFRecordDataset(files, num_parallel_reads=AUTOTUNE)
    data = data.map(decode_data, num_parallel_calls=AUTOTUNE)
    data = data.shuffle(BUFFER).batch(BATCH_SIZE, drop_remainder=True)
    data = data.prefetch(AUTOTUNE)
    return data

train_ds = load_data(file_dir=tfr_train)
valid_ds = load_data(file_dir=tfr_valid)
test_ds = load_data(file_dir=tfr_test, BATCH_SIZE=1, BUFFER=500)
```

```
def show_images(data, class_names=class_names, model=None, SIZE=(25,25), GRID=[6,6]):

    # Plot Configuration
    n_rows, n_cols = GRID
    n_images = n_rows * n_cols
    plt.figure(figsize=SIZE)

    # Iterate through the data
    i=1
    for images, labels in iter(data):

        # Select some items randomly
        id = np.random.randint(len(images))
        image, label = tf.expand_dims(images[id], axis=0), class_names[int(labels[id])]

        # Make Prediction
        if model is not None:
            pred = model.predict(image)[0]
            score = np.round(max(pred),2)
            pred_class = class_names[np.argmax(pred)]

            title = f"True : {label}\nPred : {pred_class}\n Score : {score}"
        else:
            title = label

        # plot Images
        plt.subplot(n_rows, n_cols, i)
        plt.imshow(image[0])
        plt.axis('off')
        plt.title(title)

        # Break Loop
        i+=1
        if i>n_images:
            break

    # Final Show
    plt.show()
show_images(train_ds)
```


```
1 show_images(valid_ds)
```



1

Model Architecture

```
1 pip install autokeras
```

```
Requirement already satisfied: autokeras in /usr/local/lib/python3.10/dist-packages (2.0.0)
Requirement already satisfied: packaging in /usr/local/lib/python3.10/dist-packages (from autokeras) (24.1)
Requirement already satisfied: keras-tuner>=1.4.0 in /usr/local/lib/python3.10/dist-packages (from autokeras) (1.4.7)
Requirement already satisfied: keras-nlp>=0.8.0 in /usr/local/lib/python3.10/dist-packages (from autokeras) (0.12.1)
Collecting keras>=3.0.0 (from autokeras)
  Using cached keras-3.3.3-py3-none-any.whl (1.1 MB)
Requirement already satisfied: dm-tree in /usr/local/lib/python3.10/dist-packages (from autokeras) (0.1.8)
Requirement already satisfied: absl-py in /usr/local/lib/python3.10/dist-packages (from keras>=3.0.0->autokeras) (1.4.0)
Requirement already satisfied: numpy in /usr/local/lib/python3.10/dist-packages (from keras>=3.0.0->autokeras) (1.25.2)
Requirement already satisfied: rich in /usr/local/lib/python3.10/dist-packages (from keras>=3.0.0->autokeras) (13.7.1)
Requirement already satisfied: namex in /usr/local/lib/python3.10/dist-packages (from keras>=3.0.0->autokeras) (0.0.8)
Requirement already satisfied: h5py in /usr/local/lib/python3.10/dist-packages (from keras>=3.0.0->autokeras) (3.11.0)
Requirement already satisfied: optree in /usr/local/lib/python3.10/dist-packages (from keras>=3.0.0->autokeras) (0.11.0)
Requirement already satisfied: ml-dtypes in /usr/local/lib/python3.10/dist-packages (from keras>=3.0.0->autokeras) (0.3.2)
Requirement already satisfied: keras-core in /usr/local/lib/python3.10/dist-packages (from keras-nlp>=0.8.0->autokeras) (0.1.7)
Requirement already satisfied: regex in /usr/local/lib/python3.10/dist-packages (from keras-nlp>=0.8.0->autokeras) (2024.5.15)
Requirement already satisfied: kagglehub in /usr/local/lib/python3.10/dist-packages (from keras-nlp>=0.8.0->autokeras) (0.2.6)
```

```
Requirement already satisfied: tensorflow-text in /usr/local/lib/python3.10/dist-packages (from keras-nlp>=0.8.0->autokeras) (2.1
Requirement already satisfied: requests in /usr/local/lib/python3.10/dist-packages (from keras-tuner>=1.4.0->autokeras) (2.31.0)
Requirement already satisfied: kt-legacy in /usr/local/lib/python3.10/dist-packages (from keras-tuner>=1.4.0->autokeras) (1.0.5)
Requirement already satisfied: tqdm in /usr/local/lib/python3.10/dist-packages (from kagglehub->keras-nlp>=0.8.0->autokeras) (4.6
Requirement already satisfied: typing-extensions>=4.0.0 in /usr/local/lib/python3.10/dist-packages (from optree->keras>=3.0.0->au
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.10/dist-packages (from requests->keras-tuner>=1
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests->keras-tuner>=1.4.0->autoke
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.10/dist-packages (from requests->keras-tuner>=1.4.0->
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Requirement already satisfied: markdown-it-py>=2.2.0 in /usr/local/lib/python3.10/dist-packages (from rich->keras>=3.0.0->autoker
Requirement already satisfied: pygments<3.0.0,>=2.13.0 in /usr/local/lib/python3.10/dist-packages (from rich->keras>=3.0.0->autok
Collecting tensorflow<2.17,>=2.16.1 (from tensorflow-text->keras-nlp>=0.8.0->autokeras)
  Using cached tensorflow-2.16.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (589.8 MB)
Requirement already satisfied: mdurl~=0.1 in /usr/local/lib/python3.10/dist-packages (from markdown-it-py>=2.2.0->rich->keras>=3
Requirement already satisfied: astunparse>=1.6.0 in /usr/local/lib/python3.10/dist-packages (from tensorflow<2.17,>=2.16.1->tenso
Requirement already satisfied: flatbuffers>=23.5.26 in /usr/local/lib/python3.10/dist-packages (from tensorflow<2.17,>=2.16.1->te
Requirement already satisfied: gast!=0.5.0,!=0.5.1,!=0.5.2,>=0.2.1 in /usr/local/lib/python3.10/dist-packages (from tensorflow<2
Requirement already satisfied: google-pasta>=0.1.1 in /usr/local/lib/python3.10/dist-packages (from tensorflow<2.17,>=2.16.1->ter
Requirement already satisfied: libclang>=13.0.0 in /usr/local/lib/python3.10/dist-packages (from tensorflow<2.17,>=2.16.1->tensor
Requirement already satisfied: opt-einsum>=2.3.2 in /usr/local/lib/python3.10/dist-packages (from tensorflow<2.17,>=2.16.1->tenso
Requirement already satisfied: protobuf!=4.21.0,!=4.21.1,!=4.21.2,!=4.21.3,!=4.21.4,!=4.21.5,<5.0.0dev,>=3.20.3 in /usr/local/lit
Requirement already satisfied: setuptools in /usr/local/lib/python3.10/dist-packages (from tensorflow<2.17,>=2.16.1->tensorflow-t
Requirement already satisfied: six>=1.12.0 in /usr/local/lib/python3.10/dist-packages (from tensorflow<2.17,>=2.16.1->tensorflow
Requirement already satisfied: termcolor>=1.1.0 in /usr/local/lib/python3.10/dist-packages (from tensorflow<2.17,>=2.16.1->tensor
Requirement already satisfied: wrapt>=1.11.0 in /usr/local/lib/python3.10/dist-packages (from tensorflow<2.17,>=2.16.1->tensorflo
Requirement already satisfied: grpcio<2.0,>=1.24.3 in /usr/local/lib/python3.10/dist-packages (from tensorflow<2.17,>=2.16.1->ter
Collecting tensorboard<2.17,>=2.16 (from tensorflow<2.17,>=2.16.1->tensorflow-text->keras-nlp>=0.8.0->autokeras)
  Using cached tensorboard-2.16.2-py3-none-any.whl (5.5 MB)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in /usr/local/lib/python3.10/dist-packages (from tensorflow<2
Requirement already satisfied: wheel<1.0,>=0.23.0 in /usr/local/lib/python3.10/dist-packages (from astunparse>=1.6.0->tensorflow<
Requirement already satisfied: markdown>=2.6.8 in /usr/local/lib/python3.10/dist-packages (from tensorboard<2.17,>=2.16->tensorfl
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in /usr/local/lib/python3.10/dist-packages (from tensorboard
Requirement already satisfied: werkzeug>=1.0.1 in /usr/local/lib/python3.10/dist-packages (from tensorboard<2.17,>=2.16->tensorfl
Requirement already satisfied: MarkupSafe>=2.1.1 in /usr/local/lib/python3.10/dist-packages (from werkzeug>=1.0.1->tensorboard<2
Installing collected packages: tensorboard, keras, tensorflow
  Attempting uninstall: tensorboard
    Found existing installation: tensorboard 2.15.2
    Uninstalling tensorboard-2.15.2:
      Successfully uninstalled tensorboard-2.15.2
  Attempting uninstall: keras
```

```
1 pip install tensorflow-hub
```

```
Requirement already satisfied: tensorflow-hub in /usr/local/lib/python3.10/dist-packa
Requirement already satisfied: numpy>=1.12.0 in /usr/local/lib/python3.10/dist-packag
Requirement already satisfied: protobuf>=3.19.6 in /usr/local/lib/python3.10/dist-pac
Requirement already satisfied: tf-keras>=2.14.1 in /usr/local/lib/python3.10/dist-pac
Collecting tensorflow<2.16,>=2.15 (from tf-keras>=2.14.1->tensorflow-hub)
  Using cached tensorflow-2.15.1-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_
Requirement already satisfied: absl-py>=1.0.0 in /usr/local/lib/python3.10/dist-packa
Requirement already satisfied: astunparse>=1.6.0 in /usr/local/lib/python3.10/dist-pa
Requirement already satisfied: flatbuffers>=23.5.26 in /usr/local/lib/python3.10/dist
Requirement already satisfied: gast!=0.5.0,!=0.5.1,!=0.5.2,>=0.2.1 in /usr/local/lib/
Requirement already satisfied: google-pasta>=0.1.1 in /usr/local/lib/python3.10/dist-
Requirement already satisfied: h5py>=2.9.0 in /usr/local/lib/python3.10/dist-packages
Requirement already satisfied: libclang>=13.0.0 in /usr/local/lib/python3.10/dist-pac
Requirement already satisfied: ml-dtypes~=0.3.1 in /usr/local/lib/python3.10/dist-pac
Requirement already satisfied: opt-einsum>=2.3.2 in /usr/local/lib/python3.10/dist-pa
Requirement already satisfied: packaging in /usr/local/lib/python3.10/dist-packages (
Requirement already satisfied: setuptools in /usr/local/lib/python3.10/dist-packages
Requirement already satisfied: six>=1.12.0 in /usr/local/lib/python3.10/dist-packages
Requirement already satisfied: termcolor>=1.1.0 in /usr/local/lib/python3.10/dist-pac
Requirement already satisfied: typing-extensions>=3.6.6 in /usr/local/lib/python3.10/
Requirement already satisfied: wrapt<1.15,>=1.11.0 in /usr/local/lib/python3.10/dist-
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in /usr/local/lib
Requirement already satisfied: grpcio<2.0,>=1.24.3 in /usr/local/lib/python3.10/dist-
Collecting tensorboard<2.16,>=2.15 (from tensorflow<2.16,>=2.15->tf-keras>=2.14.1->te
  Using cached tensorboard-2.15.2-py3-none-any.whl (5.5 MB)
Requirement already satisfied: tensorflow-estimator<2.16,>=2.15.0 in /usr/local/lib/p
Collecting keras<2.16,>=2.15.0 (from tensorflow<2.16,>=2.15->tf-keras>=2.14.1->tensor
  Using cached keras-2.15.0-py3-none-any.whl (1.7 MB)
Requirement already satisfied: wheel<1.0,>=0.23.0 in /usr/local/lib/python3.10/dist-p
Requirement already satisfied: google-auth<3,>=1.6.3 in /usr/local/lib/python3.10/dis
Requirement already satisfied: google-auth-oauthlib<2,>=0.5 in /usr/local/lib/python3
Requirement already satisfied: markdown>=2.6.8 in /usr/local/lib/python3.10/dist-pack
Requirement already satisfied: requests<3,>=2.21.0 in /usr/local/lib/python3.10/dist-
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in /usr/local/li
Requirement already satisfied: werkzeug>=1.0.1 in /usr/local/lib/python3.10/dist-pack
Requirement already satisfied: cachetools<6.0,>=2.0.0 in /usr/local/lib/python3.10/di
Requirement already satisfied: pyasn1-modules>=0.2.1 in /usr/local/lib/python3.10/dis
Requirement already satisfied: rsa<5,>=3.1.4 in /usr/local/lib/python3.10/dist-packag
Requirement already satisfied: requests-oauthlib>=0.7.0 in /usr/local/lib/python3.10/
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.10/
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-package
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.10/dist-p
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.10/dist-p
Requirement already satisfied: MarkupSafe>=2.1.1 in /usr/local/lib/python3.10/dist-pa
Requirement already satisfied: pyasn1<0.7.0,>=0.4.6 in /usr/local/lib/python3.10/dist
Requirement already satisfied: oauthlib>=3.0.0 in /usr/local/lib/python3.10/dist-pack
Installing collected packages: keras, tensorboard, tensorflow
  Attempting uninstall: keras
    Found existing installation: keras 3.3.3
    Uninstalling keras-3.3.3:
      Successfully uninstalled keras-3.3.3
  Attempting uninstall: tensorboard
    Found existing installation: tensorboard 2.16.2
    Uninstalling tensorboard-2.16.2:
      Successfully uninstalled tensorboard-2.16.2
  Attempting uninstall: tensorflow
    Found existing installation: tensorflow 2.16.1
    Uninstalling tensorflow-2.16.1:
      Successfully uninstalled tensorflow-2.16.1
ERROR: pip's dependency resolver does not currently take into account all the package
autokeras 2.0.0 requires keras>=3.0.0, but you have keras 2.15.0 which is incompatibl
tensorflow-text 2.16.1 requires tensorflow<2.17,>=2.16.1; platform_machine != "arm64"
Successfully installed keras-2.15.0 tensorboard-2.15.2 tensorflow-2.15.1
```

```python
import tensorflow_hub as hub
from keras.models import load_model
```

```python
import autokeras as ak
import numpy as np
import pandas as pd
from sklearn.preprocessing import LabelEncoder, normalize
from sklearn.model_selection import train_test_split
from tensorflow.keras import utils
import matplotlib.pyplot as plt
from PIL import Image
import os
```

```python
# Папка с папками картинок, рассортированных по категориям
IMAGE_PATH = '/content/drive/MyDrive/landscape/Training Data/'
# Получение списка папок, находящемуся по адресу в скобках
os.listdir(IMAGE_PATH)
```

```
# просмотр примеров изображений из разных классов
categories = os.listdir(IMAGE_PATH)

plt.figure(figsize=(6,12))

for i, category in enumerate(categories):
  # все имена файлов из папки
  file_names = os.listdir(os.path.join(IMAGE_PATH, category))

  # открываем первое изображение
  img_path = os.path.join(IMAGE_PATH, category, file_names[0])
  img = Image.open(img_path)

  # отображаем содержимое файла
  plt.subplot(4,2,i+1)
  plt.title(category)
  plt.imshow(img)

plt.tight_layout()
plt.show()
```

```
train_data = ak.image_dataset_from_directory(
    IMAGE_PATH,
    image_size = (192,108),
    seed = 111,
    validation_split = 0.2,
    subset = 'training'
)

test_data = ak.image_dataset_from_directory(
    IMAGE_PATH,
    image_size = (192,108),
    seed = 111,
    validation_split = 0.2,
    subset = 'validation'
)
```

```
clf1 = ak.ImageClassifier(max_trials=5,
                          max_model_size=42545288,
                         loss='categorical_crossentropy',
                         metrics=['accuracy'],
                         tuner='hyperband',
                         objective='val_accuracy')
hist = clf1.fit(train_data, epochs=2, validation_split=0.2)
```

```
bit = hub.KerasLayer("https://tfhub.dev/google/bit/m-r50x1/1")
model_path = '/content/drive/MyDrive/landscape/BiT-LR-91-83.h5'
model = load_model(model_path, custom_objects={"KerasLayer":bit})

```

```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 keras_layer (KerasLayer)    (32, 2048)                23500352

 dense (Dense)               (32, 5)                   10245

=================================================================
Total params: 23510597 (89.69 MB)
Trainable params: 10245 (40.02 KB)
Non-trainable params: 23500352 (89.65 MB)
_________________________________________________________________
```

```
model.evaluate(train_ds)
```

```
312/312 [==============================] - 4865s 14s/step - loss: 1.4098 - accuracy: 0.9122
[1.4097508192062378, 0.9121594429016113]
```

```
model.evaluate(valid_ds)
```

```
46/46 [==============================] - 767s 14s/step - loss: 3.0030 - accuracy: 0.8417
[3.003037452697754, 0.8417119383811951]
```

```
model.evaluate(test_ds)
```

```
500/500 [==============================] - 309s 445ms/step - loss: 1.8340 - accuracy: 0.9140
[1.833951711654663, 0.9139999747276306]
```

```
# Model Predictions
show_images(test_ds, class_names=class_names, model=model, SIZE=(25,30))
```

```
1/1 [==============================] - 2s 2s/step
1/1 [==============================] - 1s 612ms/step
1/1 [==============================] - 1s 539ms/step
1/1 [==============================] - 0s 410ms/step
1/1 [==============================] - 0s 386ms/step
1/1 [==============================] - 0s 410ms/step
1/1 [==============================] - 0s 412ms/step
1/1 [==============================] - 0s 400ms/step
1/1 [==============================] - 0s 396ms/step
1/1 [==============================] - 0s 410ms/step
1/1 [==============================] - 0s 390ms/step
1/1 [==============================] - 0s 421ms/step
1/1 [==============================] - 0s 399ms/step
1/1 [==============================] - 0s 406ms/step
1/1 [==============================] - 0s 389ms/step
1/1 [==============================] - 0s 396ms/step
1/1 [==============================] - 0s 397ms/step
1/1 [==============================] - 0s 394ms/step
1/1 [==============================] - 0s 426ms/step
1/1 [==============================] - 0s 396ms/step
1/1 [==============================] - 0s 411ms/step
1/1 [==============================] - 0s 403ms/step
1/1 [==============================] - 0s 412ms/step
1/1 [==============================] - 1s 553ms/step
1/1 [==============================] - 1s 604ms/step
1/1 [==============================] - 1s 599ms/step
1/1 [==============================] - 1s 589ms/step
1/1 [==============================] - 1s 603ms/step
1/1 [==============================] - 1s 611ms/step
1/1 [==============================] - 1s 627ms/step
1/1 [==============================] - 0s 483ms/step
1/1 [==============================] - 0s 401ms/step
1/1 [==============================] - 0s 402ms/step
1/1 [==============================] - 0s 395ms/step
1/1 [==============================] - 0s 391ms/step
1/1 [==============================] - 0s 383ms/step
```