Лабораторная работа №5

Применение сверточных нейронных сетей (бинарная классификация)

Набор данных *DogsVsCats*, который состоит из изображений различной размерности, содержащих фотографии собак и кошек.

Обучающая выборка включает в себя 25 тыс. изображений (12,5 тыс. кошек: *cat.0.jpg*, ..., *cat.12499.jpg* и 12,5 тыс. собак: *dog.0.jpg*, …, *dog.12499.jpg*), а контрольная выборка содержит 12,5 тыс. неразмеченных изображений.

Скачать данные, а также проверить качество классификатора на тестовой выборке можно на сайте *Kaggle*: https://www.kaggle.com/c/dogs-vs-cats/data (https://www.kaggle.com/c/dogs-vs-cats/data)

Задание 1

Загрузите данные. Разделите исходный набор данных на обучающую, валидационную и контрольную выборки.

In [1]:

```
from google.colab import drive

drive.mount('/content/drive', force_remount = True)
```

```
Mounted at /content/drive
```

In [0]:

```
BASE_DIR = '/content/drive/My Drive/Colab Files/mo-2/dogs-vs-cats'

import sys

sys.path.append(BASE_DIR)

import os
```

In [0]:

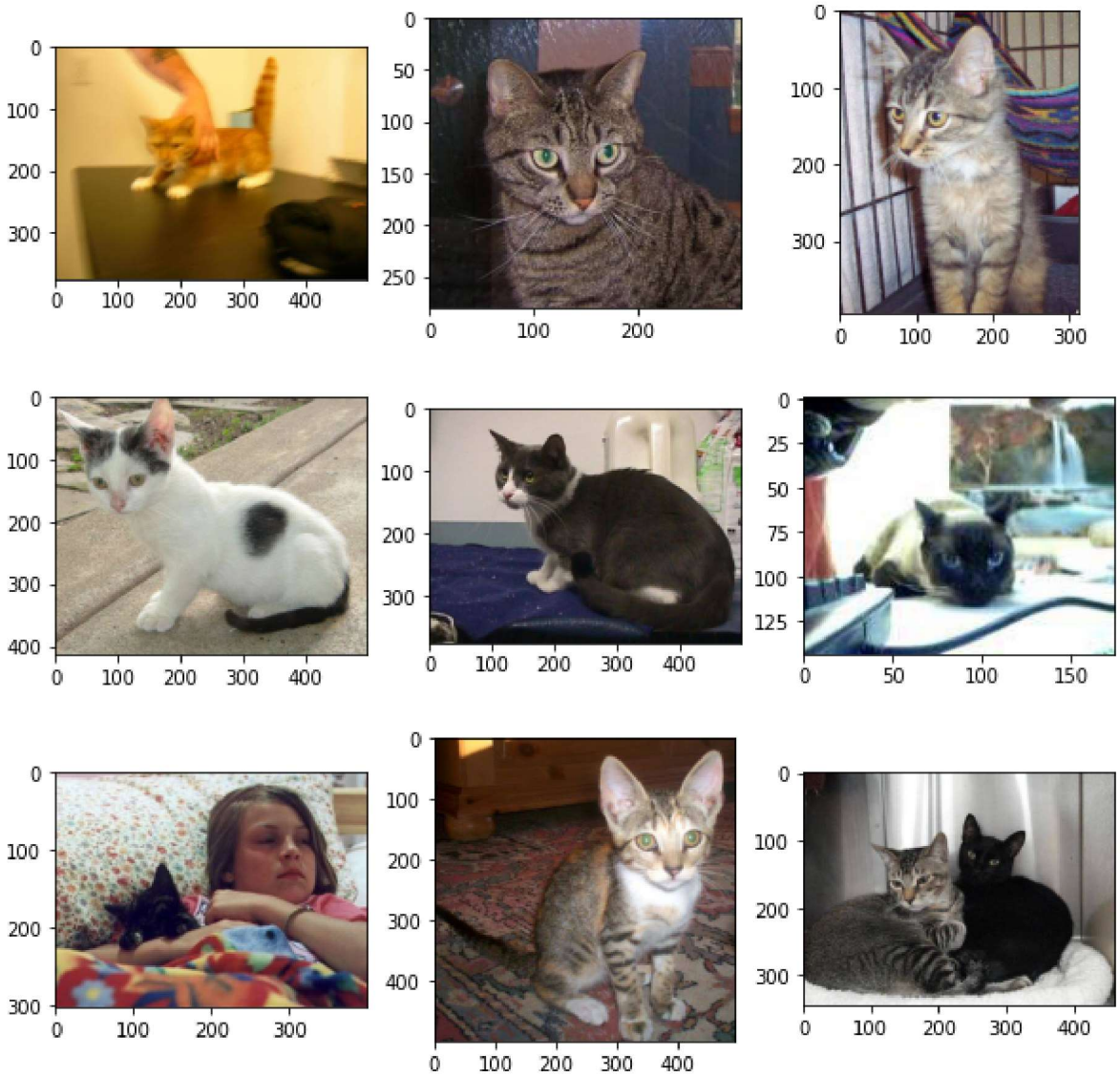
```
TRAIN_ARCHIVE_NAME = 'train.zip'
TEST_ARCHIVE_NAME = 'test1.zip'

LOCAL_DIR_NAME = 'dogs-vs-cats'
```

In [0]:

```
from zipfile import ZipFile

with ZipFile(os.path.join(BASE_DIR, TRAIN_ARCHIVE_NAME), 'r') as zip_:
    zip_.extractall(path = os.path.join(LOCAL_DIR_NAME, 'train'))

with ZipFile(os.path.join(BASE_DIR, TEST_ARCHIVE_NAME), 'r') as zip_:
    zip_.extractall(path = os.path.join(LOCAL_DIR_NAME, 'test-1'))
```

In [5]:

```
from matplotlib import pyplot
from matplotlib.image import imread

pyplot.rcParams["figure.figsize"] = (10, 10)

dir_ = 'dogs-vs-cats/train/train'

for i in range(9):

    pyplot.subplot(330 + 1 + i)

    image_ = imread('{}/cat.{}.jpg'.format(dir_, i))

    pyplot.imshow(image_)

pyplot.show()
```



Изображения необходимо привести к одному размеру.

In [0]:

```
NEW_IMAGE_WIDTH = 100
```

In [7]:

```
from os import listdir
from os.path import join
from numpy import asarray
from numpy import save
from keras.preprocessing.image import load_img
from keras.preprocessing.image import img_to_array

def dir_to_dataset(_dir_path):

    photos_, labels_ = [], []

    for file_ in listdir(_dir_path):

        if file_.startswith('cat'):
            label_ = 1.0
        else:
            label_ = 0.0

        photo_ = load_img(join(_dir_path, file_), target_size = (NEW_IMAGE_WIDTH, NEW_IMAGE

        photo_ = img_to_array(photo_)

        photos_.append(photo_)
        labels_.append(label_)

    photos_norm_ = tf.keras.utils.normalize(photos_, axis = 1)

    return asarray(photos_norm_), asarray(labels_)
```

```
Using TensorFlow backend.
```

In [8]:

```
! pip install tensorflow-gpu --pre --quiet

! pip show tensorflow-gpu
```

```
Name: tensorflow-gpu
Version: 2.2.0rc3
Summary: TensorFlow is an open source machine learning framework for everyon
e.
Home-page: https://www.tensorflow.org/ (https://www.tensorflow.org/)
Author: Google Inc.
Author-email: packages@tensorflow.org
License: Apache 2.0
Location: /usr/local/lib/python3.6/dist-packages
Requires: six, opt-einsum, numpy, scipy, wheel, protobuf, google-pasta, astu
nparse, wrapt, termcolor, h5py, tensorboard, gast, tensorflow-estimator, abs
l-py, keras-preprocessing, grpcio
Required-by:
```

In [0]:

```
import tensorflow as tf
```

In [0]:

```
import numpy as np
```

In [0]:

```
X_all, y_all = dir_to_dataset('dogs-vs-cats/train/train')
```

In [0]:

```
TEST_LEN_HALF = 1000
```

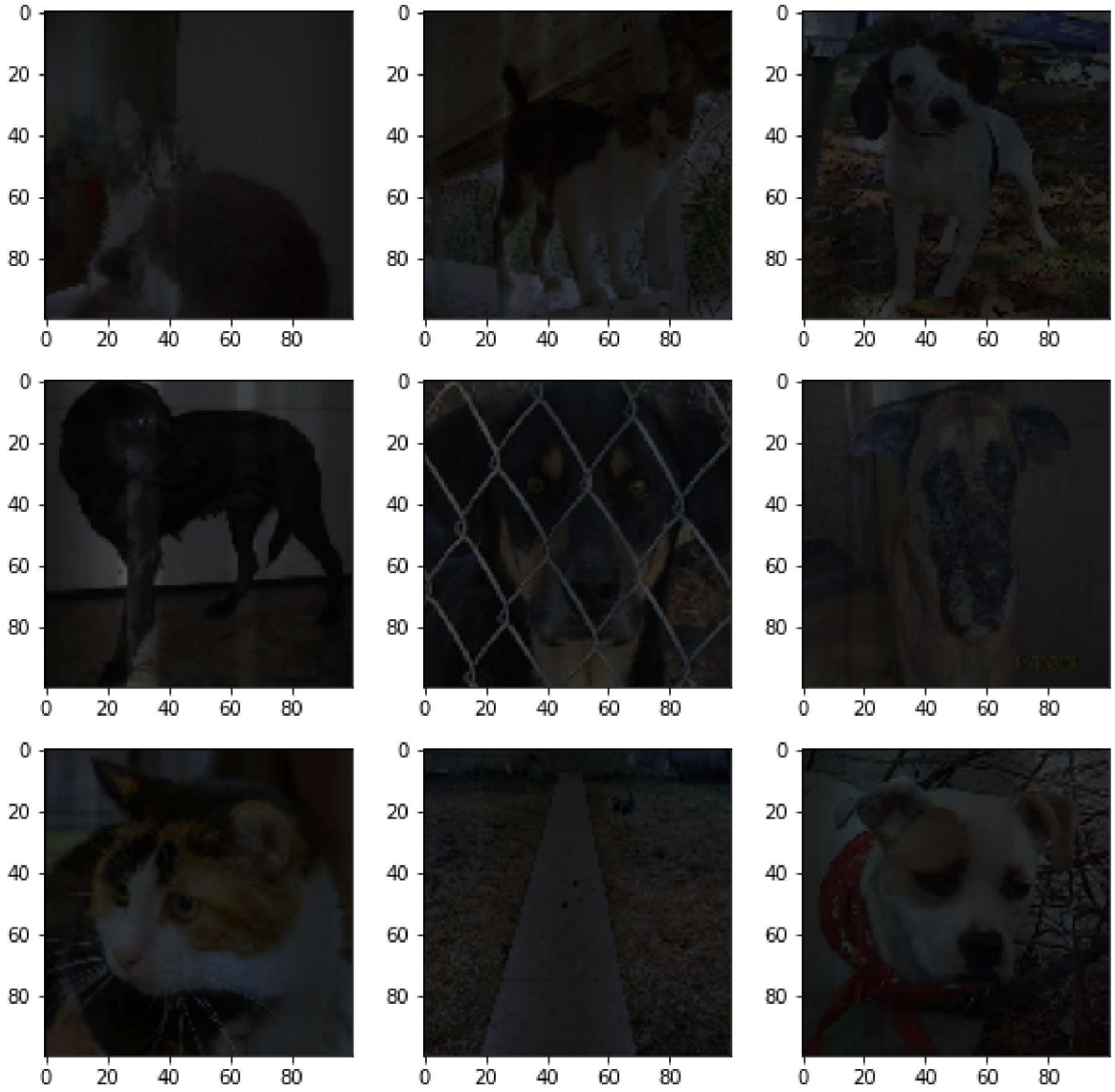
In [13]:

```
test_interval = np.r_[0:TEST_LEN_HALF, -TEST_LEN_HALF:-0]

X, y = X_all[TEST_LEN_HALF:-TEST_LEN_HALF], y_all[TEST_LEN_HALF:-TEST_LEN_HALF]
X_test, y_test = X_all[test_interval], y_all[test_interval]

print(X.shape, y.shape)
print(X_test.shape, y_test.shape)
```

```
(23000, 100, 100, 3) (23000,)
(2000, 100, 100, 3) (2000,)
```

In [14]:

```
for i in range(9):

    pyplot.subplot(330 + 1 + i)

    pyplot.imshow(X[i])

pyplot.show()
```



Выделение валидационной выборки произойдёт автоматически по параметру `validation_split` метода `model.fit()` .

Задание 2

Реализуйте глубокую нейронную сеть с как минимум тремя сверточными слоями. Какое качество классификации получено?

In [0]:

```
from tensorflow import keras
```

In [16]:

```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten, Dense

model = tf.keras.Sequential()

model.add(Conv2D(16, 3, padding = 'same', activation = 'relu', input_shape = (NEW_IMAGE_WID
model.add(MaxPooling2D())
model.add(Conv2D(32, 3, padding = 'same', activation = 'relu'))
model.add(MaxPooling2D())
model.add(Conv2D(64, 3, padding = 'same', activation = 'relu'))
model.add(MaxPooling2D())
model.add(Flatten())
model.add(Dense(512, activation = 'relu'))
model.add(Dense(1, activation = 'sigmoid'))

model.compile(optimizer = 'sgd',
              loss = 'binary_crossentropy',
              metrics = ['accuracy'])

model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 100, 100, 16)      448
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 50, 50, 16)        0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 50, 50, 32)        4640
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 25, 25, 32)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 25, 25, 64)        18496
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 12, 12, 64)        0
_________________________________________________________________
flatten (Flatten)            (None, 9216)              0
_________________________________________________________________
dense (Dense)                (None, 512)               4719104
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 513
=================================================================
Total params: 4,743,201
Trainable params: 4,743,201
Non-trainable params: 0
_________________________________________________________________
```

In [17]:

```
model.fit(x = X, y = y, epochs = 20, validation_split = 0.15)
```

```
Epoch 1/20
611/611 [==============================] - 5s 7ms/step - loss: 0.6910 - accu
racy: 0.5330 - val_loss: 0.6884 - val_accuracy: 0.5693
Epoch 2/20
611/611 [==============================] - 4s 7ms/step - loss: 0.6865 - accu
racy: 0.5647 - val_loss: 0.6819 - val_accuracy: 0.6322
Epoch 3/20
611/611 [==============================] - 4s 7ms/step - loss: 0.6805 - accu
racy: 0.5809 - val_loss: 0.6717 - val_accuracy: 0.6336
Epoch 4/20
611/611 [==============================] - 4s 7ms/step - loss: 0.6738 - accu
racy: 0.5808 - val_loss: 0.6702 - val_accuracy: 0.5719
Epoch 5/20
611/611 [==============================] - 4s 7ms/step - loss: 0.6655 - accu
racy: 0.5966 - val_loss: 0.6482 - val_accuracy: 0.6475
Epoch 6/20
611/611 [==============================] - 4s 7ms/step - loss: 0.6527 - accu
racy: 0.6171 - val_loss: 0.6380 - val_accuracy: 0.6557
Epoch 7/20
611/611 [==============================] - 4s 7ms/step - loss: 0.6378 - accu
racy: 0.6395 - val_loss: 0.6373 - val_accuracy: 0.6383
Epoch 8/20
611/611 [==============================] - 4s 7ms/step - loss: 0.6241 - accu
racy: 0.6536 - val_loss: 0.6068 - val_accuracy: 0.6841
Epoch 9/20
611/611 [==============================] - 4s 7ms/step - loss: 0.6128 - accu
racy: 0.6647 - val_loss: 0.5983 - val_accuracy: 0.6896
Epoch 10/20
611/611 [==============================] - 4s 7ms/step - loss: 0.6053 - accu
racy: 0.6741 - val_loss: 0.6148 - val_accuracy: 0.6684
Epoch 11/20
611/611 [==============================] - 4s 7ms/step - loss: 0.5972 - accu
racy: 0.6816 - val_loss: 0.6089 - val_accuracy: 0.6713
Epoch 12/20
611/611 [==============================] - 4s 7ms/step - loss: 0.5857 - accu
racy: 0.6942 - val_loss: 0.5799 - val_accuracy: 0.7052
Epoch 13/20
611/611 [==============================] - 4s 7ms/step - loss: 0.5761 - accu
racy: 0.6972 - val_loss: 0.6049 - val_accuracy: 0.6748
Epoch 14/20
611/611 [==============================] - 4s 7ms/step - loss: 0.5627 - accu
racy: 0.7119 - val_loss: 0.5664 - val_accuracy: 0.7087
Epoch 15/20
611/611 [==============================] - 4s 7ms/step - loss: 0.5504 - accu
racy: 0.7217 - val_loss: 0.5417 - val_accuracy: 0.7391
Epoch 16/20
611/611 [==============================] - 4s 7ms/step - loss: 0.5363 - accu
racy: 0.7303 - val_loss: 0.5456 - val_accuracy: 0.7264
Epoch 17/20
611/611 [==============================] - 4s 7ms/step - loss: 0.5231 - accu
racy: 0.7423 - val_loss: 0.5623 - val_accuracy: 0.7006
Epoch 18/20
611/611 [==============================] - 4s 7ms/step - loss: 0.5147 - accu
racy: 0.7442 - val_loss: 0.5286 - val_accuracy: 0.7368
Epoch 19/20
611/611 [==============================] - 4s 7ms/step - loss: 0.5017 - accu
racy: 0.7559 - val_loss: 0.5169 - val_accuracy: 0.7475
```

```
Epoch 20/20
611/611 [==============================] - 4s 7ms/step - loss: 0.4890 - accu
racy: 0.7633 - val_loss: 0.5155 - val_accuracy: 0.7487
```

Out[17]:

```
<tensorflow.python.keras.callbacks.History at 0x7fa01a7c4358>
```

In [18]:

```
results = model.evaluate(X_test, y_test)

print('Test loss, test accuracy:', results)
```

```
63/63 [==============================] - 0s 4ms/step - loss: 0.4963 - accura
cy: 0.7505
Test loss, test accuracy: [0.4963347613811493, 0.7505000233650208]
```

Результат — 75% на тестовой выборке.

Задание 3

Примените дополнение данных (*data augmentation*). Как это повлияло на качество классификатора?

In [0]:

```
def augment_image(image):

  image = tf.image.convert_image_dtype(image, tf.float32)
  image = tf.image.resize_with_crop_or_pad(image, NEW_IMAGE_WIDTH + 40, NEW_IMAGE_WIDTH + 4
  image = tf.image.random_crop(image, size = [NEW_IMAGE_WIDTH, NEW_IMAGE_WIDTH, 3])

  return image.numpy()
```

In [20]:

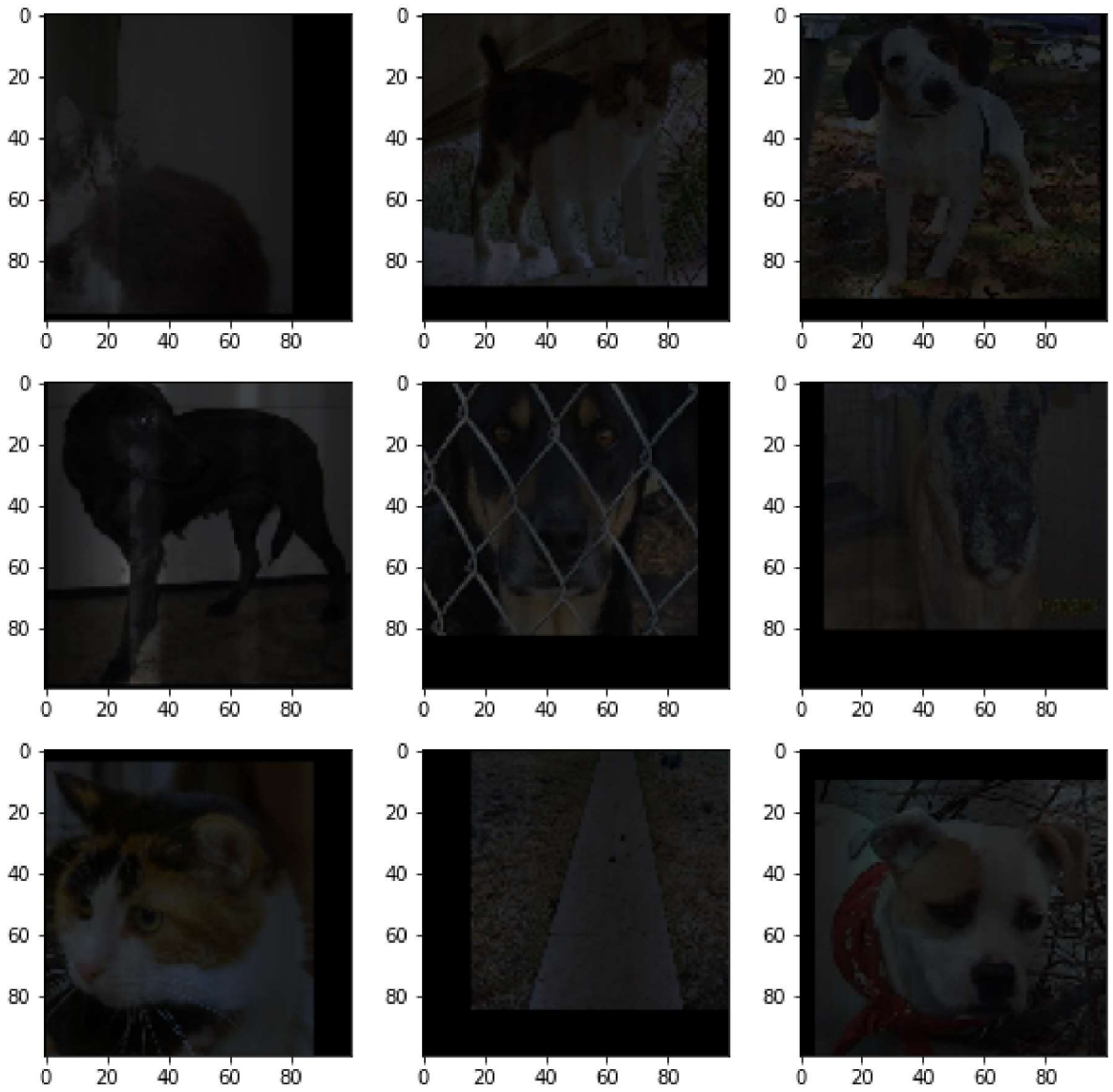
```
X_augmented = np.zeros_like(X)

for i, img in enumerate(X):

    X_augmented[i] = augment_image(img)

X_augmented.shape
```

Out[20]:

```
(23000, 100, 100, 3)
```

In [21]:

```
for i in range(9):

    pyplot.subplot(330 + 1 + i)

    pyplot.imshow(X_augmented[i])

pyplot.show()
```



In [0]:

```
y_augmented = y
```

In [23]:

```
model.fit(x = X_augmented, y = y_augmented, epochs = 20, validation_split = 0.15)
```

```
Epoch 1/20
611/611 [==============================] - 4s 7ms/step - loss: 0.6068 - accu
racy: 0.6690 - val_loss: 0.5740 - val_accuracy: 0.7000
Epoch 2/20
611/611 [==============================] - 4s 7ms/step - loss: 0.5807 - accu
racy: 0.6941 - val_loss: 0.5641 - val_accuracy: 0.7110
Epoch 3/20
611/611 [==============================] - 4s 7ms/step - loss: 0.5697 - accu
racy: 0.7006 - val_loss: 0.5608 - val_accuracy: 0.7157
Epoch 4/20
611/611 [==============================] - 4s 7ms/step - loss: 0.5559 - accu
racy: 0.7105 - val_loss: 0.5525 - val_accuracy: 0.7200
Epoch 5/20
611/611 [==============================] - 4s 7ms/step - loss: 0.5443 - accu
racy: 0.7204 - val_loss: 0.5469 - val_accuracy: 0.7212
Epoch 6/20
611/611 [==============================] - 4s 7ms/step - loss: 0.5325 - accu
racy: 0.7330 - val_loss: 0.5758 - val_accuracy: 0.6991
Epoch 7/20
611/611 [==============================] - 4s 7ms/step - loss: 0.5196 - accu
racy: 0.7426 - val_loss: 0.5517 - val_accuracy: 0.7067
Epoch 8/20
611/611 [==============================] - 4s 7ms/step - loss: 0.5080 - accu
racy: 0.7480 - val_loss: 0.5318 - val_accuracy: 0.7354
Epoch 9/20
611/611 [==============================] - 4s 7ms/step - loss: 0.4939 - accu
racy: 0.7575 - val_loss: 0.5328 - val_accuracy: 0.7278
Epoch 10/20
611/611 [==============================] - 4s 7ms/step - loss: 0.4813 - accu
racy: 0.7673 - val_loss: 0.5384 - val_accuracy: 0.7296
Epoch 11/20
611/611 [==============================] - 4s 7ms/step - loss: 0.4676 - accu
racy: 0.7761 - val_loss: 0.5519 - val_accuracy: 0.7133
Epoch 12/20
611/611 [==============================] - 4s 7ms/step - loss: 0.4524 - accu
racy: 0.7871 - val_loss: 0.5521 - val_accuracy: 0.7162
Epoch 13/20
611/611 [==============================] - 4s 7ms/step - loss: 0.4373 - accu
racy: 0.7955 - val_loss: 0.5264 - val_accuracy: 0.7406
Epoch 14/20
611/611 [==============================] - 4s 7ms/step - loss: 0.4180 - accu
racy: 0.8090 - val_loss: 0.5300 - val_accuracy: 0.7386
Epoch 15/20
611/611 [==============================] - 4s 7ms/step - loss: 0.3987 - accu
racy: 0.8180 - val_loss: 0.6854 - val_accuracy: 0.6788
Epoch 16/20
611/611 [==============================] - 4s 7ms/step - loss: 0.3834 - accu
racy: 0.8274 - val_loss: 0.5405 - val_accuracy: 0.7377
Epoch 17/20
611/611 [==============================] - 4s 7ms/step - loss: 0.3588 - accu
racy: 0.8413 - val_loss: 0.5376 - val_accuracy: 0.7400
Epoch 18/20
611/611 [==============================] - 4s 7ms/step - loss: 0.3368 - accu
racy: 0.8551 - val_loss: 0.5803 - val_accuracy: 0.7209
Epoch 19/20
611/611 [==============================] - 4s 7ms/step - loss: 0.3151 - accu
racy: 0.8673 - val_loss: 0.5872 - val_accuracy: 0.7287
```

```
Epoch 20/20
611/611 [==============================] - 4s 7ms/step - loss: 0.2849 - accu
racy: 0.8827 - val_loss: 0.5898 - val_accuracy: 0.7235
```

Out[23]:

```
<tensorflow.python.keras.callbacks.History at 0x7fa0e319d470>
```

In [24]:

```
results_2 = model.evaluate(X_test, y_test)

print('Test loss, test accuracy:', results_2)
```

```
63/63 [==============================] - 0s 4ms/step - loss: 0.5276 - accura
cy: 0.7670
Test loss, test accuracy: [0.5276018381118774, 0.7670000195503235]
```

После того, как сеть обучилась на тех же данных, к которым был применён data augmentation, точность предсказания на тестовой выборке увеличилась ненамного — до 76%.

Задание 4

Поэкспериментируйте с готовыми нейронными сетями (например, *AlexNet*, *VGG16*, *Inception* и т.п.), применив передаточное обучение. Как это повлияло на качество классификатора?

Какой максимальный результат удалось получить на сайте *Kaggle*? Почему?