Лабораторная работа №3. Реализация сверточной нейронной сети

In [1]:

```
from __future__ import absolute_import, division, print_function, unicode_literals

# TensorFlow и tf.keras
# !python3 -m pip install keras
import tensorflow as tf
from tensorflow import keras
from keras import regularizers
from keras.layers import Dense, Conv2D, Flatten


# Вспомогательные библиотеки
import numpy as np
import matplotlib.pyplot as plt
import pdb
from six.moves import cPickle as pickle
import os
from scipy import ndimage
```

```
Using TensorFlow backend.
```

In [2]:

```
def extract_dataset():
    with open('../data/notMNIST_sanit.pickle', 'rb') as f:
        data = pickle.load(f)

    # reshape dataset because of error:
    # ValueError: Error when checking input: expected conv2d_input to have 4 dimens
    # but got array with shape (200000, 28, 28)
    for key, dataset in data.items():
        data[key] = dataset.reshape(*dataset.shape, 1)
    return data
```

In [3]:

```
dataset = extract_dataset()
train_images = dataset['train_dataset']
train_labels = dataset['train_labels']
valid_images = dataset['valid_dataset']
valid_labels = dataset['valid_labels']
test_images = dataset['test_dataset']
test_labels = dataset['test_labels']
```

Задание 1. Реализуйте нейронную сеть с двумя сверточными слоями, и одним полносвязным с нейронами с кусочно-линейной функцией активации. Какова точность построенное модели?

In [4]:

```
# kernel_size=3 – размер ядра 3х3.
# Функция активации 'relu' ( Rectified Linear Activation ),
# 64 это число ядер свертки( сколько признаком будем искать).
# Flatten() – слой, преобразующий 2D-данные в 1D-данные.
conv2d_model = keras.Sequential([
    keras.layers.Conv2D(8, kernel_size=3, activation='relu', input_shape=(28, 28, 1
    keras.layers.Conv2D(16, kernel_size=3, activation='relu', input_shape=(28, 28,
    keras.layers.Flatten(),
    keras.layers.Dense(100, activation='relu'),
    keras.layers.Dense(10, activation='softmax')
])

conv2d_model.compile(optimizer='sgd',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

conv2d_model.summary()

conv2d_history = conv2d_model.fit(train_images,
                                  train_labels,
                                  epochs=10,
                                  validation_data=(valid_images, valid_labels))

test_loss, test_acc = conv2d_model.evaluate(test_images,  test_labels, verbose=2)

print('\nТочность на проверочных данных:', test_acc)
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv2d (Conv2D)              (None, 26, 26, 8)         80        
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 24, 24, 16)        1168      
_________________________________________________________________
flatten (Flatten)            (None, 9216)              0         
_________________________________________________________________
dense (Dense)                (None, 100)               921700    
_________________________________________________________________
dense_1 (Dense)              (None, 10)                1010      
=================================================================
Total params: 923,958
Trainable params: 923,958
Non-trainable params: 0
_________________________________________________________________
Train on 200000 samples, validate on 16911 samples
Epoch 1/10
200000/200000 [==============================] - 79s 395us/sample - lo
ss: 0.5508 - accuracy: 0.8404 - val_loss: 0.4634 - val_accuracy: 0.865
9
Epoch 2/10
200000/200000 [==============================] - 81s 406us/sample - lo
ss: 0.3841 - accuracy: 0.8866 - val_loss: 0.4068 - val_accuracy: 0.885
1
Epoch 3/10
200000/200000 [==============================] - 81s 403us/sample - lo
ss: 0.3310 - accuracy: 0.9018 - val_loss: 0.3706 - val_accuracy: 0.895
7
Epoch 4/10
```

```
200000/200000 [==============================] - 81s 404us/sample - lo
ss: 0.2978 - accuracy: 0.9114 - val_loss: 0.3543 - val_accuracy: 0.898
6
Epoch 5/10
200000/200000 [==============================] - 81s 405us/sample - lo
ss: 0.2725 - accuracy: 0.9183 - val_loss: 0.3469 - val_accuracy: 0.901
2
Epoch 6/10
200000/200000 [==============================] - 81s 405us/sample - lo
ss: 0.2511 - accuracy: 0.9244 - val_loss: 0.3455 - val_accuracy: 0.904
5
Epoch 7/10
200000/200000 [==============================] - 81s 405us/sample - lo
ss: 0.2317 - accuracy: 0.9302 - val_loss: 0.3467 - val_accuracy: 0.900
8
Epoch 8/10
200000/200000 [==============================] - 81s 405us/sample - lo
ss: 0.2134 - accuracy: 0.9354 - val_loss: 0.3429 - val_accuracy: 0.904
3
Epoch 9/10
200000/200000 [==============================] - 81s 404us/sample - lo
ss: 0.1960 - accuracy: 0.9405 - val_loss: 0.3523 - val_accuracy: 0.903
4
Epoch 10/10
200000/200000 [==============================] - 81s 407us/sample - lo
ss: 0.1791 - accuracy: 0.9458 - val_loss: 0.3586 - val_accuracy: 0.903
6
8722/8722 - 1s - loss: 0.1543 - accuracy: 0.9559

Точность на проверочных данных: 0.95585877
```

Задание 2. Замените один из сверточных слоев на слой, реализующий операцию пулинга (Pooling) с функцией максимума или среднего. Как это повлияло на точность классификатора?

Helpful links: https://neurohive.io/ru/osnovy-data-science/glubokaya-svertochnaja-nejronnaja-set/ (https://neurohive.io/ru/osnovy-data-science/glubokaya-svertochnaja-nejronnaja-set/)
https://medium.com/@congyuzhou/pooling-%D1%81%D0%BB%D0%BE%D0%B9-dbe00ef48eab (https://medium.com/@congyuzhou/pooling-%D1%81%D0%BB%D0%BE%D0%B9-dbe00ef48eab)

In [5]:

```
maxpool_model = keras.Sequential([
    keras.layers.Conv2D(8, kernel_size=3, activation='relu', input_shape=(28, 28, 1
    keras.layers.MaxPooling2D(),
    keras.layers.Flatten(),
    keras.layers.Dense(100, activation='relu'),
    keras.layers.Dense(10, activation='softmax')
])

maxpool_model.compile(optimizer='sgd',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

maxpool_model.summary()

maxpool_history = maxpool_model.fit(train_images,
                                      train_labels,
                                      epochs=10,
                                      validation_data=(valid_images, valid_labels))

test_loss, test_acc = maxpool_model.evaluate(test_images,  test_labels, verbose=2)

print('\nТочность на проверочных данных:', test_acc)
```

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv2d_2 (Conv2D)            (None, 26, 26, 8)         80        
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 13, 13, 8)         0         
_________________________________________________________________
flatten_1 (Flatten)          (None, 1352)              0         
_________________________________________________________________
dense_2 (Dense)              (None, 100)               135300    
_________________________________________________________________
dense_3 (Dense)              (None, 10)                1010      
=================================================================
Total params: 136,390
Trainable params: 136,390
Non-trainable params: 0
_________________________________________________________________
Train on 200000 samples, validate on 16911 samples
Epoch 1/10
200000/200000 [==============================] - 36s 178us/sample - lo
ss: 0.6299 - accuracy: 0.8208 - val_loss: 0.5312 - val_accuracy: 0.845
4
Epoch 2/10
200000/200000 [==============================] - 35s 177us/sample - lo
ss: 0.4515 - accuracy: 0.8668 - val_loss: 0.4581 - val_accuracy: 0.866
2
Epoch 3/10
200000/200000 [==============================] - 36s 178us/sample - lo
ss: 0.4034 - accuracy: 0.8808 - val_loss: 0.4335 - val_accuracy: 0.875
4
Epoch 4/10
200000/200000 [==============================] - 36s 178us/sample - lo
ss: 0.3748 - accuracy: 0.8895 - val_loss: 0.4133 - val_accuracy: 0.882
3
Epoch 5/10
```

```
200000/200000 [==============================] - 36s 178us/sample - lo
ss: 0.3542 - accuracy: 0.8961 - val_loss: 0.3980 - val_accuracy: 0.885
6
Epoch 6/10
200000/200000 [==============================] - 36s 178us/sample - lo
ss: 0.3383 - accuracy: 0.9007 - val_loss: 0.3845 - val_accuracy: 0.889
4
Epoch 7/10
200000/200000 [==============================] - 36s 179us/sample - lo
ss: 0.3249 - accuracy: 0.9039 - val_loss: 0.3844 - val_accuracy: 0.888
8
Epoch 8/10
200000/200000 [==============================] - 35s 177us/sample - lo
ss: 0.3133 - accuracy: 0.9075 - val_loss: 0.3717 - val_accuracy: 0.892
2
Epoch 9/10
200000/200000 [==============================] - 36s 178us/sample - lo
ss: 0.3033 - accuracy: 0.9103 - val_loss: 0.3718 - val_accuracy: 0.892
0
Epoch 10/10
200000/200000 [==============================] - 36s 178us/sample - lo
ss: 0.2941 - accuracy: 0.9129 - val_loss: 0.3657 - val_accuracy: 0.896
0
8722/8722 - 1s - loss: 0.1731 - accuracy: 0.9493

Точность на проверочных данных: 0.94932353
```

Задание 3. Реализуйте классическую архитектуру сверточных сетей LeNet-5 (http://yann.lecun.com/exdb/lenet/) (http://yann.lecun.com/exdb/lenet/)).

padding: https://medium.com/@congyuzhou/padding-32266fa95816 (https://medium.com/@congyuzhou/padding-32266fa95816) https://medium.com/@congyuzhou/lenet-5-%D1%81%D0%B2%D0%BE%D0%B8%D0%BC%D0%B8-%D1%80%D1%83%D0%BA%D0%B0%D0%BC%D0%B8-b60ae3727cd3 (https://medium.com/@congyuzhou/lenet-5-%D1%81%D0%B2%D0%BE%D0%B8%D0%BC%D0%B8-%D1%80%D1%83%D0%BA%D0%B0%D0%BC%D0%B8-b60ae3727cd3)

In [6]:

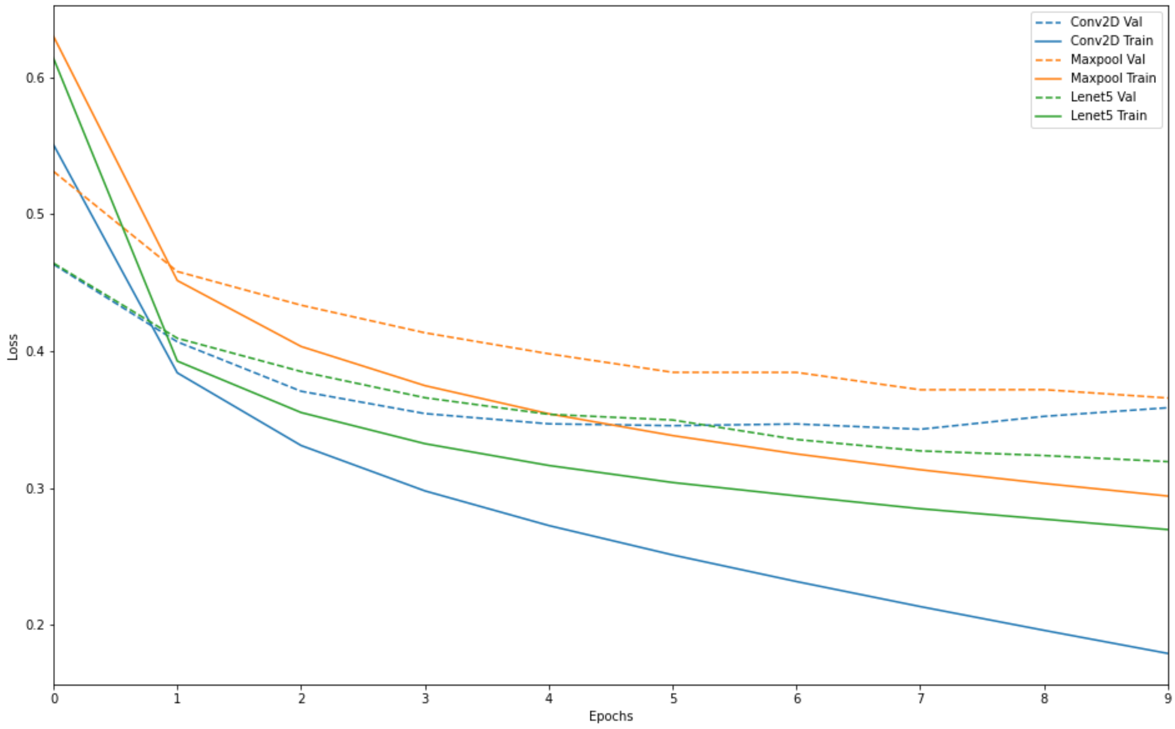
```
# stride - шаг
lenet5_model = keras.Sequential([
    keras.layers.Conv2D(filters=6, kernel_size=[5,5], padding='same', activation='r
    keras.layers.MaxPooling2D(pool_size=[2,2], strides=2),
    keras.layers.Conv2D(filters=16, kernel_size=[5,5], padding='valid', activation=
    keras.layers.MaxPooling2D(pool_size=[2,2], strides=2),
    keras.layers.Flatten(),
    keras.layers.Dense(units=120, activation='relu'),
    keras.layers.Dense(units=84, activation='relu'),
    keras.layers.Dense(units=10, activation = 'softmax')
])

lenet5_model.compile(optimizer='sgd',
                    loss='sparse_categorical_crossentropy',
                    metrics=['accuracy'])

lenet5_history = lenet5_model.fit(train_images,
                                    train_labels,
                                    epochs=10,
                                    validation_data=(valid_images, valid_labels))

lenet5_model.summary()


test_loss, test_acc = lenet5_model.evaluate(test_images,  test_labels, verbose=2)

print('\nТочность на проверочных данных:', test_acc)
```

```
Train on 200000 samples, validate on 16911 samples
Epoch 1/10
200000/200000 [==============================] - 67s 336us/sample - lo
ss: 0.6139 - accuracy: 0.8175 - val_loss: 0.4642 - val_accuracy: 0.865
0
Epoch 2/10
200000/200000 [==============================] - 67s 336us/sample - lo
ss: 0.3927 - accuracy: 0.8833 - val_loss: 0.4094 - val_accuracy: 0.879
8
Epoch 3/10
200000/200000 [==============================] - 68s 339us/sample - lo
ss: 0.3551 - accuracy: 0.8929 - val_loss: 0.3850 - val_accuracy: 0.885
6
Epoch 4/10
200000/200000 [==============================] - 67s 337us/sample - lo
ss: 0.3323 - accuracy: 0.8997 - val_loss: 0.3659 - val_accuracy: 0.892
1
Epoch 5/10
200000/200000 [==============================] - 68s 338us/sample - lo
ss: 0.3164 - accuracy: 0.9040 - val_loss: 0.3538 - val_accuracy: 0.895
5
Epoch 6/10
200000/200000 [==============================] - 68s 338us/sample - lo
ss: 0.3040 - accuracy: 0.9075 - val_loss: 0.3497 - val_accuracy: 0.896
6
Epoch 7/10
200000/200000 [==============================] - 68s 338us/sample - lo
ss: 0.2942 - accuracy: 0.9105 - val_loss: 0.3354 - val_accuracy: 0.900
5
Epoch 8/10
```

```
200000/200000 [==============================] - 68s 338us/sample - lo
ss: 0.2848 - accuracy: 0.9132 - val_loss: 0.3271 - val_accuracy: 0.901
0
Epoch 9/10
200000/200000 [==============================] - 68s 342us/sample - lo
ss: 0.2772 - accuracy: 0.9145 - val_loss: 0.3237 - val_accuracy: 0.903
0
Epoch 10/10
200000/200000 [==============================] - 68s 340us/sample - lo
ss: 0.2696 - accuracy: 0.9169 - val_loss: 0.3192 - val_accuracy: 0.904
7
Model: "sequential_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv2d_3 (Conv2D)            multiple                  156       
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 multiple                  0         
_________________________________________________________________
conv2d_4 (Conv2D)            multiple                  2416      
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 multiple                  0         
_________________________________________________________________
flatten_2 (Flatten)          multiple                  0         
_________________________________________________________________
dense_4 (Dense)              multiple                  48120     
_________________________________________________________________
dense_5 (Dense)              multiple                  10164     
_________________________________________________________________
dense_6 (Dense)              multiple                  850       
=================================================================
Total params: 61,706
Trainable params: 61,706
Non-trainable params: 0
_________________________________________________________________
8722/8722 - 1s - loss: 0.1430 - accuracy: 0.9539

Точность на проверочных данных: 0.95390964
```

In [7]:

```
def plot_history(histories, key='binary_crossentropy'):
    plt.figure(figsize=(16,10))

    for name, history in histories:
        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.xlabel('Epochs')
    plt.ylabel(key.replace('_',' ').title())
    plt.legend()

    plt.xlim([0,max(history.epoch)])

    plt.show()

plot_history(
    [
        ('conv2d', conv2d_history),
        ('maxpool', maxpool_history),
        ('lenet5', lenet5_history)
    ],
    key='loss')
```



In [ ]: