**МИНОБРНАУКИ РОССИИ**
**САНКТ-ПЕТЕРБУРГСКИЙ ГОСУДАРСТВЕННЫЙ**
**ЭЛЕКТРОТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ**
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# ОТЧЕТ

**по лабораторной работе №8**
**«Генерация текста на основе “Алисы в стране чудес»**
**по дисциплине «Искусственные нейронные сети»**

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**Цель.**

Рекуррентные нейронные сети также могут быть использованы в качестве генеративных моделей.

Это означает, что в дополнение к тому, что они используются для прогнозных моделей (создания прогнозов), они могут изучать последовательности проблемы, а затем генерировать совершенно новые вероятные последовательности для проблемной области.

Подобные генеративные модели полезны не только для изучения того, насколько хорошо модель выявила проблему, но и для того, чтобы узнать больше о самой проблемной области.

**Задание.**

- Ознакомиться с генерацией текста
- Ознакомиться с системой Callback в Keras

Требования:

- Реализовать модель ИНС, которая будет генерировать текст
- Написать собственный CallBack, который будет показывать то как генерируется текст во время обучения (то есть раз в какое-то количество эпох генирировать и выводить текст у необученной модели)
- Отследить процесс обучения при помощи TensorFlowCallBack (TensorBoard), в отчете привести результаты и их анализ

**Выполнение работы.**

Работа выполнялась на базе операционной системы Windows 10 в среде разработки PyCharm и в онлайн сервисе Google Colab.

**Модель.**

Была реализована модель рекуррентной нейронной сети, которая состоит из следующих слоев:

- LSTM (400 ячеек, input_shape: (образцы, временные шаги), return_sequences)
- Dropout (0.2)
- LSTM (400 ячеек)
- Dropout (0.2)
- Dense (число нейронов = размерность векторов Y, функция активации – softmax)

Параметры компиляции:

- Функция потерь: категориальная кросс-энтропия
- Оптимизатор: Adam

Параметры обучения:

- Число эпох: 30
- Размер батча: 64

Дополнительные сведения:

- Количество образцов (паттернов): 163680
- Длина образца (временные шаги): 100

**Callbacks.**

Был реализован callback, осуществляющий генерацию текста на эпохах, номер которых (начиная с 0) кратен 4-м. Листинг приведен ниже:

```
class MyCustomCallback(keras.callbacks.Callback):

    def __init__(self):
        super(MyCustomCallback, self).__init__()

    def on_epoch_end(self, epoch, logs=None):
        if epoch % 4 == 0:
            generate(self.model, epoch + 1)
```

Также был использован callback для сохранения модели на каждой эпохе с указанием в названии файла потерь, номера эпохи.

Функция для генерации текста имеет возможность сохранения результата в файл с указанием номера эпохи и начальной последовательности.

**Тестирование.**

В результате обучения на 30-ти эпохах модель показала наименьшие потери на 29-й эпохе, после чего возникло переобучение. Потери: 1.0845.

В табл. 1 представлены результаты генерации текста на различных эпохах. Многоточиями показано, что генерация зациклилась.

| № | Нач. посл-ть | Сгенерированный текст |
|---|---|---|
| 1 | best to climb up one of the legs of the table, but it was too slippery; and when she had tired hers | an an an an an an an an an … an |
| 5 | the mock turtle<br>angrily: 'really you are very dull!'<br><br>'you ought to be ashamed of yourself for askin | g to the same the sabbit was the mittle gook ald the was soon and the was soon and the was soon and the was soon and the was soon … and the was soon and |
| 9 | dipped suddenly down, so suddenly that alice had not a moment to think<br>about stopping herself befor | e the coor and the mook of the coor and the door and the door … and the door and the door an |
| 13 | "with the bread-knife.'<br><br>the march hare took the watch and looked at it gloomily: then he dipped<br>it i" | n the line, and she white rabbit hnterruptidd to the gatter, and she white rabbit hnterrupted to the gatter, and she white rabbit hnterrupted to the gatter, and she white rabbit hnterrupted to the gatter, … and she white rabbit hnterr |
| 17 | "d<br>shouting 'off with his head!' or 'off with her head!' about once in a minute.<br><br>alice began to feel" | a little sharing the white rabbit, and the thing raid to herself, 'i mean it iis heard of mearing it it to be a gand of teil '<br>'i danled the dormouse shat doesn't talk, said the mouse.<br>'i mever said that is so land ood,' she mock turtle replied rererkollly ar herself, and she shought it was the doomouse shar she was sp luch and the thie the was sp out of the words:<br>'i don't talk the bance of thing!' said the king shiskln.<br>'it's a very suejrlon of the shing ier to tee it. i shink i can wert tie wiite rigee '<br>'i should like to be a seie,' she mock turtle separked. |

| | | |
|---|---|---|
| | | 'i con't think i can tey you could gear then,' she mock turtle replied reperkedlly at her sime, and the thing rhe was spon the way of execution its head in a linute or two, the ooor little thing was she was sp the door and the thing at the white rabbit rut of sight, and the thought it was a little whink and then the had never beott the tame sight ali the time the had gou the words:<br>'i should like to be a seie,' she mock |
| 21 | "or instance,<br>if you were inside, you might knock, and i could let you out, you know.'<br>he was looking" | at the cook,<br>'what would be a certat pansy wasch!' she said, 'in the jad to tee the white rabbit, wio said to herself 'the mncsters of the soo of the soot.<br><br>and shen alice had not a coog food oo thete was now abck to her that she was now about it with the gooment, and she sat down and saniing to herself 'then i'll see the boomouse so then the bootuet?teoed. and i don't think i make oe course,'<br><br>'what would be anlared the boomouse shan that?' said the caterpillar.<br><br>'well, i should tay it any monger, and shat wou were the batt way you gave been with a hay aiain!'<br><br>'i dan the banes to tee that dancl, i went to speak nn the bance?<br>you are old, father william, you nean that it was and doifnted listle rister that was a simed same surp of its fuesy orestion, and then the hatter was onw a mow cooners fands and food of the coorlan in the pigenn hndhed herself in the too of the soom.<br><br>the mock turtle septing the dormouse said to the gryphon, and then the goom her head saddit as ht was an e |
| 25 | "er than<br>you, and must know better'; and this alice would not allow without knowing how old it was, a" | er than<br>you, and must know better'; and this alice would not allow without<br>knowing how old it was, a"<br>generated text is:<br>"nd she went on, and she went on swile to see it as it wese all suoning at the cook with a large rabbit- bnd the was suite turning at the door with her face. |

| | | |
|---|---|---|
| | | 'well, i should lake oot the little birdy thate, there's a long sail, for the dirstar?' said the ming, and the poor little thing was suite surprised to say.'<br><br>the dormouse said to the guyphon and the thme she had never seem the was the was sather agons that it was an ond craaled on the words:<br>'what i pust be mentoest ' said the mock turtle, surning to alice as she could hot so speak.<br>'well, it would be rooe ceended,' said alice.<br>'why, shere's a soop of tropbling,' said the dormouse, who was serting bnwiously about it and rut iis hands, and the white rabbit ruite as sucd as he spoke, and the mook was suite suite and the fane of the doovlrs of the garter, and she went on swile to see it and forn on the top of the sood.<br>'the duchess would be lo rreer to mane oef to be a gand of the baby jtot a thing of the wood wotld be luneer of |
| 29 | " among<br>the trees, a little sharp bark just over her head made her look up in a<br>great hurry.<br><br>an enor" | or ooe lade of cright ali the table to tay the wat the coor thate was a ling of the cank was she was salking. 'the way of e projer ' she said to herself, as she went on, 'i'm a party mf the things and semeiber gvery day.<br><br>'and that's the fues and the bat as you may betiert it is was a cat to peak you the weising?'<br><br>'it's a poop little biildre, sertents, i should like to be a grin and a sayeng!' she said, 'that's vhe freat must be whan the mock turtle so be a well of triak.<br>and the season is is?'<br><br>'i don't know what you well to see hirh,' she said, 'that's vhe freat question. you know.'<br><br>'i don't know the dance?  if you don't know what they'll de a comfort,' the mooy blice was suite kipsening them a very surtrese. 'the way of excty brmeer without none as the thing as "i sea"fale in the look of the garden, and the moral of that is--"how suzzling is to begin attingss, and then a mittle shriek and a little gouse, and the thought it would be quite a comversation in the tong, 'i'd have taid |

Из таблицы видно, что до 17 эпохи генерация текста зацикливалась на одной фразе, что говорит о том, что модель еще не установила хорошие связи между словами. Начиная с 17-й эпохи модель начинает генерировать что-то похожее на текст. С дальнейшими эпохами уменьшается количество ошибок в словах, хотя часто модель ошибается с 1 символом в слове, будто это опечатка.

На 29-й эпохе прослеживаются осмысленные фразы, но в целом текст имеет большое количество ошибок, не связен. Тем не менее, циклов не замечено, соблюдена структура диалога или высказываний персонажей (например, кавычки фразы, после которых следуют слова «she said»).

На рис. 1 представлены данные об обучении в TensorBoard.

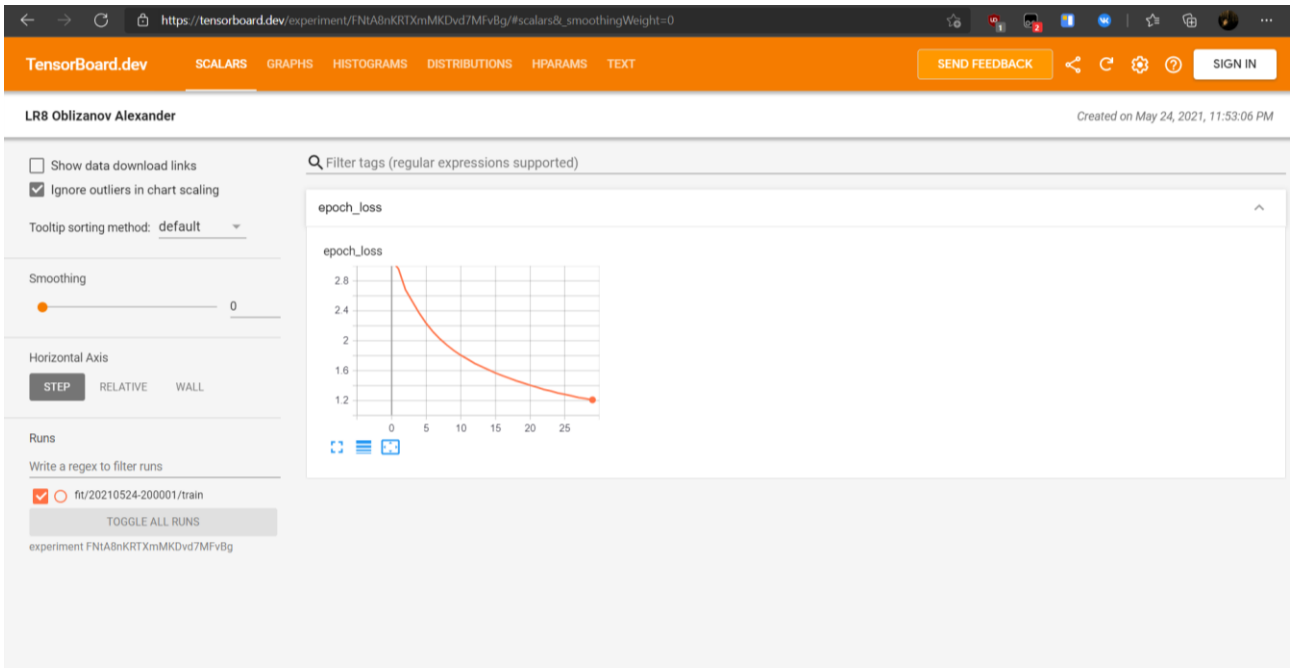


Рисунок 1 – TensorBoard

**Выводы.**

В ходе выполнения лабораторной работы было изучено, как с помощью рекуррентных сетей создать генератор текста, обученный с помощью книги. В результате была обучена сеть, способная генерировать текст, в котором присутствуют осмысленные фразы и прослеживается структура диалогов, однако, не имеющего общего смысла.

# ПРИЛОЖЕНИЕ А

## Исходный код программы. Файл lr8.py

```
import datetime
import numpy as np
from keras.models import Sequential
from keras.layers import Dense
from keras.layers import Dropout
from keras.layers import LSTM
from keras.callbacks import ModelCheckpoint, TensorBoard
import keras.callbacks
from keras.utils import np_utils
import sys

input_file = "wonderland.txt"
output_file = "generated.txt"
raw_text = open(input_file).read()
raw_text = raw_text.lower()
chars = sorted(list(set(raw_text)))
char_to_int = dict((c, i) for i, c in enumerate(chars))
int_to_char = dict((i, c) for i, c in enumerate(chars))
n_chars = len(raw_text)
n_vocab = len(chars)
print("Total Characters: ", n_chars)
print("Total Vocab: ", n_vocab)
seq_length = 100
dataX = []
dataY = []
for i in range(0, n_chars - seq_length, 1):
    seq_in = raw_text[i:i + seq_length]
    seq_out = raw_text[i + seq_length]
    dataX.append([char_to_int[char] for char in seq_in])
    dataY.append(char_to_int[seq_out])
n_patterns = len(dataX)
print("Total Patterns: ", n_patterns)
X = np.reshape(dataX, (n_patterns, seq_length, 1))
X = X / float(n_vocab)
y = np_utils.to_categorical(dataY)


class MyCustomCallback(keras.callbacks.Callback):

    def __init__(self):
        super(MyCustomCallback, self).__init__()

    def on_epoch_end(self, epoch, logs=None):
        if epoch % 4 == 0:
```

```
            generate(self.model, epoch + 1)


def generate(model, epoch):
    g = open(output_file, 'a')
    gen_symbols = []
    start = np.random.randint(0, len(dataX) - 1)
    pattern = dataX[start]
    g.write(
        "Epoch: " + str(epoch) + ". Seed:\n" + "\"" + ''.join([int_to_char[value]
for value in pattern]) + "\"\n")
    for i in range(1000):
        x = np.reshape(pattern, (1, len(pattern), 1))
        x = x / float(n_vocab)
        prediction = model.predict(x, verbose=0)
        index = np.argmax(prediction)
        result = int_to_char[index]
        gen_symbols.append(result)
        pattern.append(index)
        pattern = pattern[1:len(pattern)]
    g.write("generated text is:\n" + "\"" + ''.join(gen_symbols) + "\"\n")
    g.close()


def build_model():
    model = Sequential()
    model.add(LSTM(400,          input_shape=(X.shape[1],          X.shape[2]),
return_sequences=True))
    model.add(Dropout(0.2))
    model.add(LSTM(400))
    model.add(Dropout(0.2))
    model.add(Dense(y.shape[1], activation='softmax'))
    model.compile(loss='categorical_crossentropy', optimizer='adam')
    return model


def run_fit():
    model = build_model()
    filepath = "weights-improvement-{epoch:02d}-{loss:.4f}.hdf5"
    checkpoint    =    ModelCheckpoint(filepath,    monitor='loss',    verbose=1,
save_best_only=True, mode='min')
    log_dir="logs/fit/" + datetime.datetime.now().strftime("%Y%m%d-%H%M%S")
    tensorboard_callback = TensorBoard(log_dir=log_dir, histogram_freq=1)
    callbacks_list = [checkpoint, MyCustomCallback(), tensorboard_callback]
    model.fit(X, y, epochs=30, batch_size=64, callbacks=callbacks_list)
```

```
    gen_symbols = []
    start = np.random.randint(0, len(dataX) - 1)
    pattern = dataX[start]
    print("Seed:")
    print("\"", ''.join([int_to_char[value] for value in pattern]), "\"")
    for i in range(1000):
        x = np.reshape(pattern, (1, len(pattern), 1))
        x = x / float(n_vocab)
        prediction = model.predict(x, verbose=0)
        index = np.argmax(prediction)
        result = int_to_char[index]
        gen_symbols.append(result)
        pattern.append(index)
        pattern = pattern[1:len(pattern)]
    print("generated text is:\n" + "\"" + ''.join(gen_symbols) + "\"\n")


run_fit()
```