ЯПИИ 2024

Лабораторная работа 1

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Постановка задачи

Задачи:

. Установить tensorflow 2. Создать трансформерную сеть для определения местоположения объектов относительно друг друга.

. Сделать возможность сравнения (как в VQA) местоположения объектов друг с другом.

. Relational reasoning – датасет CLEVR.

. Зарегистрировать GitHub аккаунт

Выполнение работы

1. Установка tensorflow 2.

```
!pip install tensorflow
```

```
import json
import numpy as np
import tensorflow as tf
import matplotlib.pyplot as plt
from sklearn.preprocessing import LabelEncoder
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
```

1.2 - Предварительная обработка данных .

. Извлечение информации о местоположениях объектов из файлов json.

```
with open(r'/content/CLEVR_train_scenes.json', 'r') as f:
    train_scenes = json.load(f)
with open(r'/content/CLEVR_train_questions.json', 'r') as f:
    train_questions = json.load(f)
with open(r'/content/CLEVR_val_scenes.json', 'r') as f:
    val_scenes = json.load(f)
with open(r'/content/CLEVR_val_questions.json', 'r') as f:
    val_questions = json.load(f)
```

```
all_questions = [q['question'] for q in train_questions['questions'] + val_questions['questions']]
print("Combined questions for tokenization")

question_tokenizer = Tokenizer(oov_token='<OOV>')
question_tokenizer.fit_on_texts(all_questions)
print("Tokenizer initialized")

X_train_questions_seq = question_tokenizer.texts_to_sequences([q['question'] for q in train_questions['questions']])
X_val_questions_seq = question_tokenizer.texts_to_sequences([q['question'] for q in val_questions['questions']])
print("Train & Val seq converted")

max_question_length = max(len(seq) for seq in X_train_questions_seq + X_val_questions_seq)
X_train_questions_padded = pad_sequences(X_train_questions_seq, maxlen=max_question_length, padding='post')
X_val_questions_padded = pad_sequences(X_val_questions_seq, maxlen=max_question_length, padding='post')
```

```
Combined questions for tokenization
Tokenizer initialized
Train & Val seq converted
```

```
def extract_features(scene):
    features = []
    for obj in scene['objects']:
        attributes = [obj['size'], obj['color'], obj['material'], obj['shape']]
        features.extend(attributes)
    return features

def prep_dataset(scenes, questions):
    X = []
    y = []
    s_dict = {scene['image_index']: scene for scene in scenes['scenes']}
    for question in questions['questions']:
        image_index = question['image_index']
        if image_index in s_dict:
            scene = s_dict[image_index]
            features = extract_features(scene)
            X.append(features)
            y.append(question['answer'])
    return X, y

X_train_scenes_raw, y_train_raw = prep_dataset(train_scenes, train_questions)
X_val_scenes_raw, y_val_raw = prep_dataset(val_scenes, val_questions)
print("Train & Val data extracted")

all_features = [item for sublist in X_train_scenes_raw + X_val_scenes_raw for item in sublist]
scene_encoder = LabelEncoder()
scene_encoder.fit(all_features)

X_train_scenes_encoded = [scene_encoder.transform(features) for features in X_train_scenes_raw]
X_val_scenes_encoded = [scene_encoder.transform(features) for features in X_val_scenes_raw]

max_scene_length = max(len(seq) for seq in X_train_scenes_encoded + X_val_scenes_encoded)
X_train_scenes_padded = pad_sequences(X_train_scenes_encoded, maxlen=max_scene_length, padding='post')
X_val_scenes_padded = pad_sequences(X_val_scenes_encoded, maxlen=max_scene_length, padding='post')
```

```
Train & Val data extracted
```

. Кодирование всех слоев.

```
all_answers = y_train_raw + y_val_raw

label_encoder = LabelEncoder()
label_encoder.fit(all_answers)

y_train_encoded = label_encoder.transform(y_train_raw)
y_val_encoded = label_encoder.transform(y_val_raw)
```

4.Модель

```
q_input = tf.keras.layers.Input(shape=(max_question_length,), name='question_input')
q_embedding = tf.keras.layers.Embedding(
    input_dim=len(question_tokenizer.word_index) + 1,
    output_dim=128,
    mask_zero=True
)(q_input)
question_lstm = tf.keras.layers.LSTM(64)(q_embedding)



s_input = tf.keras.layers.Input(shape=(max_scene_length,), name='scene_input')
s_embedding = tf.keras.layers.Embedding(
    input_dim=len(scene_encoder.classes_),
    output_dim=128,
    mask_zero=True
)(s_input)
scene_lstm = tf.keras.layers.LSTM(64)(s_embedding)


combined = tf.keras.layers.concatenate([question_lstm, scene_lstm])
fc1 = tf.keras.layers.Dense(64, activation='relu')(combined)
output = tf.keras.layers.Dense(len(label_encoder.classes_), activation='softmax')(fc1)
model = tf.keras.models.Model(inputs=[q_input, s_input], outputs=output)
```

. компиляция

```
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['accuracy'])
```

```
model.summary()
```

```
Model: "functional"
```

Layer (type)	Output Shape	Param #	Connected to
question_input (InputLayer)	(None, 43)	0	-
scene_input (InputLayer)	(None, 40)	0	-
embedding (Embedding)	(None, 43, 128)	10,496	question_input[0][0]
not_equal (NotEqual)	(None, 43)	0	question_input[0][0]
embedding_1 (Embedding)	(None, 40, 128)	1,920	scene_input[0][0]
not_equal_1 (NotEqual)	(None, 40)	0	scene_input[0][0]
lstm (LSTM)	(None, 64)	49,408	embedding[0][0], not_equal[0][0]
lstm_1 (LSTM)	(None, 64)	49,408	embedding_1[0][0], not_equal_1[0][0]
concatenate (Concatenate)	(None, 128)	0	lstm[0][0], lstm_1[0][0]
dense (Dense)	(None, 64)	8,256	concatenate[0][0]
dense_1 (Dense)	(None, 28)	1,820	dense[0][0]

5- обучение модели

```
history = model.fit(
    {'question_input': X_train_questions_padded, 'scene_input': X_train_scenes_padded},
    y_train_encoded,
    epochs=10,
    batch_size=32,
    validation_data=(
        {'question_input': X_val_questions_padded, 'scene_input': X_val_scenes_padded},
        y_val_encoded
    )
)
```

```
Epoch 1/10
21875/21875 ━━━━━━━━━━━━━━━━━━━━ 688s 31ms/step - accuracy: 0.4592 - loss: 1.0576 - val_accuracy: 0.5292 - val_loss: 0.8806
Epoch 2/10
21875/21875 ━━━━━━━━━━━━━━━━━━━━ 597s 25ms/step - accuracy: 0.5320 - loss: 0.8729 - val_accuracy: 0.5384 - val_loss: 0.8607
Epoch 3/10
21875/21875 ━━━━━━━━━━━━━━━━━━━━ 542s 24ms/step - accuracy: 0.5435 - loss: 0.8512 - val_accuracy: 0.5444 - val_loss: 0.8476
Epoch 4/10
21875/21875 ━━━━━━━━━━━━━━━━━━━━ 577s 24ms/step - accuracy: 0.5502 - loss: 0.8393 - val_accuracy: 0.5484 - val_loss: 0.8346
Epoch 5/10
21875/21875 ━━━━━━━━━━━━━━━━━━━━ 531s 24ms/step - accuracy: 0.5548 - loss: 0.8285 - val_accuracy: 0.5540 - val_loss: 0.8285
Epoch 6/10
21875/21875 ━━━━━━━━━━━━━━━━━━━━ 527s 23ms/step - accuracy: 0.5580 - loss: 0.8231 - val_accuracy: 0.5567 - val_loss: 0.8243
Epoch 7/10
21875/21875 ━━━━━━━━━━━━━━━━━━━━ 463s 21ms/step - accuracy: 0.5596 - loss: 0.8181 - val_accuracy: 0.5562 - val_loss: 0.8230
Epoch 8/10
21875/21875 ━━━━━━━━━━━━━━━━━━━━ 473s 20ms/step - accuracy: 0.5633 - loss: 0.8136 - val_accuracy: 0.5625 - val_loss: 0.8203
Epoch 9/10
21875/21875 ━━━━━━━━━━━━━━━━━━━━ 457s 21ms/step - accuracy: 0.5648 - loss: 0.8107 - val_accuracy: 0.5630 - val_loss: 0.8160
Epoch 10/10
21875/21875 ━━━━━━━━━━━━━━━━━━━━ 432s 18ms/step - accuracy: 0.5674 - loss: 0.8084 - val_accuracy: 0.5602 - val_loss: 0.8156
```

6- Построение графика train & validation : accuracy & loss.

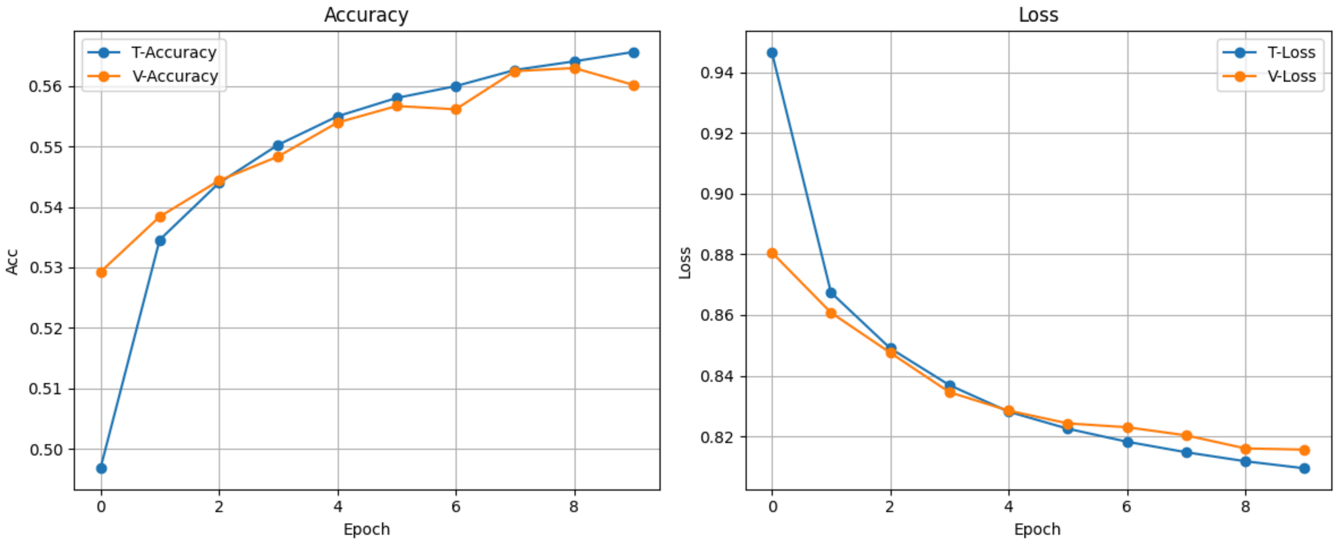
```
plt.figure(figsize=(12, 5))

plt.subplot(1, 2, 1)
plt.plot(history.history['accuracy'], label='T-Accuracy', marker='o')
plt.plot(history.history['val_accuracy'], label='V-Accuracy', marker='o')
plt.title('Accuracy')
plt.xlabel('Epoch')
plt.ylabel('Acc')
plt.legend()
plt.grid(True)

plt.subplot(1, 2, 2)
plt.plot(history.history['loss'], label='T-Loss', marker='o')
plt.plot(history.history['val_loss'], label='V-Loss', marker='o')
plt.title('Loss')
```

```
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()
plt.grid(True)

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



7- Визуализация прогнозов

```
indices = np.random.choice(len(X_val_questions_padded), 5, replace=False)

test_questions = X_val_questions_padded[indices]
test_scenes = X_val_scenes_padded[indices]
test_labels = y_val_encoded[indices]

predict = model.predict({'question_input': test_questions, 'scene_input': test_scenes})
predicted = np.argmax(predict, axis=1)

for i, idx in enumerate(indices):
    question_text = val_questions['questions'][idx]['question']
    true_answer = label_encoder.inverse_transform([test_labels[i]])[0]
    pred_answer = label_encoder.inverse_transform([predicted[i]])[0]
    print(f"---------------------------------------------------------------------------\nQuestion: {question_text}\nTrue Answer: {true_ar
```

```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 18ms/step
---------------------------------------------------------------------------
Question: There is a rubber thing that is the same size as the green ball; what shape is it?
True Answer: sphere
Predicted Answer: sphere
---------------------------------------------------------------------------

---------------------------------------------------------------------------
Question: Do the tiny cylinder that is to the right of the purple cylinder and the big gray cube have the same material?
True Answer: no
Predicted Answer: no
---------------------------------------------------------------------------

---------------------------------------------------------------------------
Question: What is the size of the thing that is on the right side of the shiny object in front of the tiny metal object left of the
True Answer: large
Predicted Answer: small
---------------------------------------------------------------------------

---------------------------------------------------------------------------
Question: The green object in front of the large purple ball that is in front of the purple sphere to the left of the small brown me
True Answer: rubber
Predicted Answer: rubber
---------------------------------------------------------------------------

---------------------------------------------------------------------------
Question: How many other objects are there of the same size as the yellow shiny block?
True Answer: 2
Predicted Answer: 0
---------------------------------------------------------------------------
```

Напишите программный код или сгенерируйте его с помощью искусственного интеллекта.