

ADL hw1

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Q1: Data processing

1. Tokenizer

- (a) Character Segmentation:
split the input text into individual character and consider them as basic units.
- (b) Word Segmentation:
segment Chinese words(composed of multiple characters) into subword tokens
- (c) special tokens
 - i. CLS token is usually added at the beginning of the input
 - ii. SEP token is used to separate segments of text in tasks like question-answering or text classification
 - iii. UNK to represent out-of-vocabulary terms

2. Answer Span

- (a) iterate through the list of tokens and determine which tokens cover the character positions of the answer span.
Start with the start_char position. Check which token covers this character position, if the character position is within the boundaries of a token, consider that token as the starting token. Repeat the same process for the end_char position to find the ending token.
- (b) The BERT model predicts the probability distribution for all token positions for the start and end of the answer span.
To determine the start and end position of answer span, choose the token position with the highest probability

Q2: Modeling with BERTs and their variants

1. Model with bert

- (a) paragraph selection

```
1 {  
2   "_name_or_path": "bert-base-chinese",  
3   "architectures": [  
4     "BertForMultipleChoice"  
5   ],  
6   "attention_probs_dropout_prob": 0.1,
```

```

7   "classifier_dropout": null,
8   "directionality": "bidi",
9   "hidden_act": "gelu",
10  "hidden_dropout_prob": 0.1,
11  "hidden_size": 768,
12  "initializer_range": 0.02,
13  "intermediate_size": 3072,
14  "layer_norm_eps": 1e-12,
15  "max_position_embeddings": 512,
16  "model_type": "bert",
17  "num_attention_heads": 12,
18  "num_hidden_layers": 12,
19  "pad_token_id": 0,
20  "pooler_fc_size": 768,
21  "pooler_num_attention_heads": 12,
22  "pooler_num_fc_layers": 3,
23  "pooler_size_per_head": 128,
24  "pooler_type": "first_token_transform",
25  "position_embedding_type": "absolute",
26  "torch_dtype": "float32",
27  "transformers_version": "4.34.0",
28  "type_vocab_size": 2,
29  "use_cache": true,
30  "vocab_size": 21128
31 }

```

(b) span selection

```

1  {
2    "_name_or_path": "bert-base-chinese",
3    "architectures": [
4      "BertForQuestionAnswering"
5    ],
6    "attention_probs_dropout_prob": 0.1,
7    "classifier_dropout": null,
8    "directionality": "bidi",
9    "hidden_act": "gelu",
10   "hidden_dropout_prob": 0.1,
11   "hidden_size": 768,
12   "initializer_range": 0.02,
13   "intermediate_size": 3072,
14   "layer_norm_eps": 1e-12,
15   "max_position_embeddings": 512,
16   "model_type": "bert",
17   "num_attention_heads": 12,
18   "num_hidden_layers": 12,
19   "pad_token_id": 0,
20   "pooler_fc_size": 768,

```

```

21  "pooler_num_attention_heads": 12,
22  "pooler_num_fc_layers": 3,
23  "pooler_size_per_head": 128,
24  "pooler_type": "first_token_transform",
25  "position_embedding_type": "absolute",
26  "torch_dtype": "float32",
27  "transformers_version": "4.34.0",
28  "type_vocab_size": 2,
29  "use_cache": true,
30  "vocab_size": 21128
31  }

```

(c) performance:

- i. phase1:
validation accuracy: 0.9564639415088069
- ii. phase2:
validation exact match: 79.76071784646062

(d) loss function: cross entropy loss

(e) optimization algorithm: adamw

(f) Hyperparameter

- i. phase1:
learning rate: 2e-5
batch size: 2
- ii. phase2:
learning rate: 1e-5
batch size: 4

2. Model with shibing624/text2vec-base-chinese

(a) paragraph selection

```

1  {
2    "_name_or_path": "shibing624/text2vec-base-chinese",
3    "architectures": [
4      "BertForMultipleChoice"
5    ],
6    "attention_probs_dropout_prob": 0.1,
7    "classifier_dropout": null,
8    "directionality": "bidi",
9    "gradient_checkpointing": false,
10   "hidden_act": "gelu",
11   "hidden_dropout_prob": 0.1,
12   "hidden_size": 768,
13   "initializer_range": 0.02,
14   "intermediate_size": 3072,
15   "layer_norm_eps": 1e-12,
16   "max_position_embeddings": 512,

```

```

17  "model_type": "bert",
18  "num_attention_heads": 12,
19  "num_hidden_layers": 12,
20  "pad_token_id": 0,
21  "pooler_fc_size": 768,
22  "pooler_num_attention_heads": 12,
23  "pooler_num_fc_layers": 3,
24  "pooler_size_per_head": 128,
25  "pooler_type": "first_token_transform",
26  "position_embedding_type": "absolute",
27  "torch_dtype": "float32",
28  "transformers_version": "4.34.0",
29  "type_vocab_size": 2,
30  "use_cache": true,
31  "vocab_size": 21128
32 }

```

(b) span selection

```

1  {
2    "_name_or_path": "shibing624/text2vec-base-chinese",
3    "architectures": [
4      "BertForQuestionAnswering"
5    ],
6    "attention_probs_dropout_prob": 0.1,
7    "classifier_dropout": null,
8    "directionality": "bidi",
9    "gradient_checkpointing": false,
10   "hidden_act": "gelu",
11   "hidden_dropout_prob": 0.1,
12   "hidden_size": 768,
13   "initializer_range": 0.02,
14   "intermediate_size": 3072,
15   "layer_norm_eps": 1e-12,
16   "max_position_embeddings": 512,
17   "model_type": "bert",
18   "num_attention_heads": 12,
19   "num_hidden_layers": 12,
20   "pad_token_id": 0,
21   "pooler_fc_size": 768,
22   "pooler_num_attention_heads": 12,
23   "pooler_num_fc_layers": 3,
24   "pooler_size_per_head": 128,
25   "pooler_type": "first_token_transform",
26   "position_embedding_type": "absolute",
27   "torch_dtype": "float32",
28   "transformers_version": "4.34.0",
29   "type_vocab_size": 2,

```

```

30     "use_cache": true,
31     "vocab_size": 21128
32 }

```

(c) performance:

- i. phase1: validation accuracy: 0.9651046859421735
- ii. phase2: validation exact match: 80.62479228979727

(d) Hyperparameter

- i. phase1:
 - learning rate: 2e-5
 - batch size: 2
- ii. phase2:
 - learning rate: 1e-5
 - batch size: 4

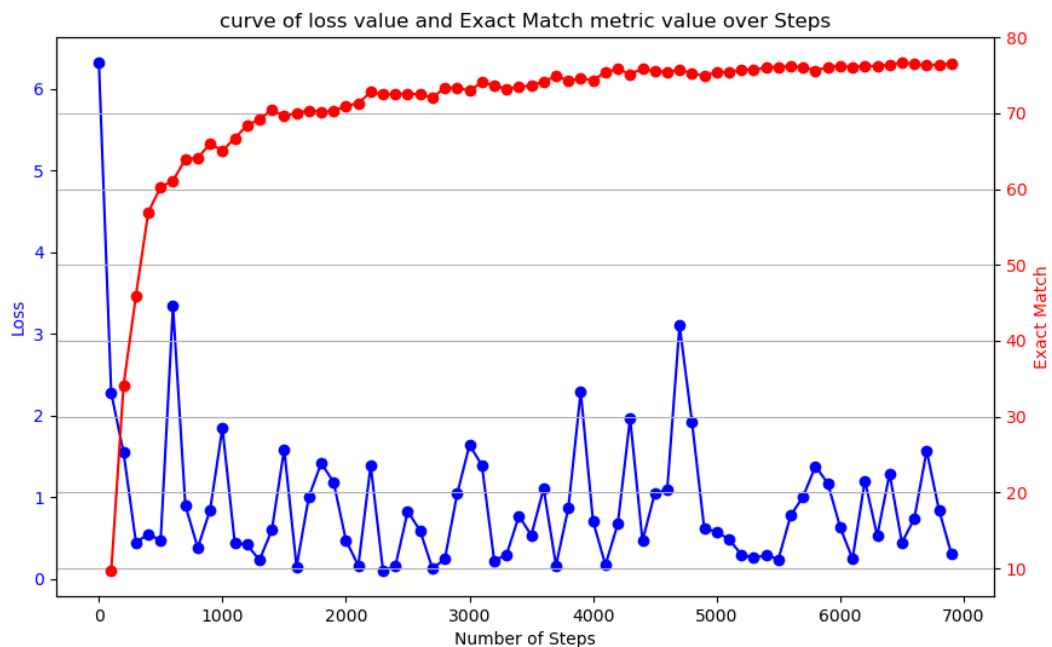
3. difference between pre-trained LMs

BERT consists of a multi-layer bidirectional encoder that processes text in both directions and having deep transformer-based model with multiple layers and the ability to capture deep contextual information, making it suitable for tasks that require understanding the context of the language.

shibing624/text2vec-base-chinese which is based on text2vec framework which include Word2Vec and Doc2Vec are shallow models including paragraph embeddings (Paragraph Vectors) that represent entire documents. this model focus on capturing word or document embeddings but doesn't have the same depth of understanding of language context as BERT.

Q3: Curves

Learning curve of the loss value and the Exact Match metric value



Q4: Pre-trained vs Not Pre-trained

1. configuration of the model

```
1 {
2     "_name_or_path": "model_bert_notrain_p2/",
3     "architectures": [
4         "BertForQuestionAnswering"
5     ],
6     "attention_probs_dropout_prob": 0.1,
7     "classifier_dropout": null,
8     "directionality": "bidi",
9     "hidden_act": "gelu",
10    "hidden_dropout_prob": 0.1,
11    "hidden_size": 768,
12    "initializer_range": 0.02,
13    "intermediate_size": 3072,
14    "layer_norm_eps": 1e-12,
15    "max_position_embeddings": 512,
16    "model_type": "bert",
17    "num_attention_heads": 12,
18    "num_hidden_layers": 12,
19    "pad_token_id": 0,
20    "pooler_fc_size": 768,
21    "pooler_num_attention_heads": 12,
22    "pooler_num_fc_layers": 3,
23    "pooler_size_per_head": 128,
24    "pooler_type": "first_token_transform",
25    "position_embedding_type": "absolute",
26    "torch_dtype": "float32",
27    "transformers_version": "4.34.0",
28    "type_vocab_size": 2,
29    "use_cache": true,
30    "vocab_size": 21128
31 }
```

2. how to train this model:

first train the model on question answering with bert and epoch 0 to get the not pre-trained model, then use the not pre-trained model just get from previous step to train with data and validation

```
python run_qa_no_trainer.py --train_file converted_train.json --validation_file
converted_valid.json --test_file converted_test.json --do_predict --
per_device_train_batch_size 4 --per_device_eval_batch_size 1 --learning_rate 1e-5
--num_train_epochs 0 --max_seq_length 512 --output_dir model_bert_notrain_p2/ --
model_name_or_path bert-base-chinese
```

```
python run_qa_no_trainer.py --train_file converted_train.json --validation_file
converted_valid.json --test_file converted_test.json --do_predict --
per_device_train_batch_size 4 --per_device_eval_batch_size 1 --learning_rate 1e-5
--num_train_epochs 1 --max_seq_length 512 --config_name model_bert_notrain_p2/ --
tokenizer_name model_bert_notrain_p2/ --output model_bert_notrain_final
```

3. performance:

(a) pre-trained: validation exact match: 3.3233632436025258

(b) not pre-trained: validation exact match: 3.3233632436025258

there is a clear difference of performance between two model, i think that means the pre-trained model play a crucial role in this kind task, it should be difficult to have proper performance by only using the train data we get without the help of pre-trained model because the size of our train data is much less compared the data use to train this pre-trained model.

Q5: Bonus

1. model:

i use the span selection model to train this end-to-end transformer-based model, by modifying the train data to combine the four paragraph(each paragraph remain first 512 characters and combine to one paragraph with 2048 characters) and change the hyperparameter `--max_seq_length 2048`

2. performance:

need more time to train and the performance still worse than the bert model with paragraph selection + span selection pipeline approach.

3. loss function, optimization algorithm, learning rate and batch size:

same as the model used in Q2 span selection model with bert.