--- title: 表文融合模型 author: 程军 吉小浩 date: 2024-6-25 format: docx: toc: true toc-title: 目 录 toc-expand: 2 number-sections: true jupyter: python3 ---

本项目旨在通过深度学习技术探索关键审计事项的识别与分析。我们采用了一种创新的方法，将KAM文本信息转化为张量，并利用深度学习模型进行特征提取和模式识别。

In [3]:
```
! python --version
! pip3.12 list | findstr "pandas torch"
```

```
Python 3.12.3
pandas                      2.2.2
torch                       2.3.1+cu121
torchaudio                  2.3.1+cu121
torchtext                   0.18.0
torchvision                 0.18.1+cu121
```

In [4]:
```
from IPython.core.interactiveshell import InteractiveShell

InteractiveShell.ast_node_interactivity = "all"
```

In [5]:
```
import torch
import torch.nn as nn
import torch.nn.functional as F
from transformers import BertModel, BertTokenizer
import evaluate
import pandas as pd
```

对接数据

初步数据

这里我们直接生成三个数据分别是X,y,text。在从CSMAR加工来的数据，可以分拆成这三个即可复用后面的代码。

这个方案主要是演示方便。

或者从CSMAR加工来的数据，得到由X，y，text组成的pandas的数据框，将数据框直接传给数据整理函数进行处理，同样可以。此时对数据整理函数作调整即可。

In [6]:
```
from sklearn.datasets import make_regression

X, y = make_regression(n_samples=640, n_features=10, noise=30, random_state=42)
```

In [7]:
```
fin_audit=pd.read_excel("rawdata/FIN_AuditDetail.xlsx")
fin_audit=fin_audit = fin_audit.drop(fin_audit.index[0:2]).reset_index(drop=True
```

```
c:\Program Files\Python312\Lib\site-packages\openpyxl\styles\stylesheet.py:226: U
serWarning: Workbook contains no default style, apply openpyxl's default
  warn("Workbook contains no default style, apply openpyxl's default")
```

In [8]:
```
fin_audit['year']=fin_audit["Accper"].str.slice(0,4)
fin_audit['Description']=fin_audit['Classification']+" "+ fin_audit['Description
```

```python
fin_audit['Method']=fin_audit['Classification']+" "+ fin_audit['Method']
fin_audit = fin_audit.loc[:, ['Stkcd', 'year', 'ItemNo', "Description", "Method"
```

In [9]:

```python
# fin_audit.groupby(['Stkcd', 'year'])['ItemNo'].transform('max').value_counts()
max_item_no = fin_audit.groupby(['Stkcd', 'year'])['ItemNo'].max()
frequency_counts = max_item_no.value_counts()
pd.DataFrame({
    'ItemNo': frequency_counts.index,
    'FrequencyCount': frequency_counts.values,
    'Frequency': (frequency_counts/frequency_counts.sum()).values,
    'CumulativeFrequencies':(frequency_counts/frequency_counts.sum()).cumsum().v
})
```

Out[9]:

	ItemNo	FrequencyCount	Frequency	CumulativeFrequencies
0	2	18334	0.649198	0.649198
1	1	5262	0.186325	0.835523
2	3	4219	0.149393	0.984916
3	4	386	0.013668	0.998584
4	5	35	0.001239	0.999823
5	6	5	0.000177	1.000000

基于上面的结果，我们可以直接保留事项为1-3的信息。

In [10]:

```python
fin_audit['ItemNo'].dtype
fin_audit['ItemNo'] = fin_audit['ItemNo'].astype('UInt8')
fin_audit = fin_audit[fin_audit["ItemNo"] <= 3]
```

Out[10]:

```
dtype('O')
```

In [11]:

```python
fin_audit_wide=fin_audit.pivot_table(index=['Stkcd', 'year'], columns='ItemNo',
fin_audit_wide.columns = [col[0]+"_"+str(col[1]) for col in fin_audit_wide.colum
fin_audit_wide=fin_audit_wide.reset_index()

# 填补缺失值
fin_audit_wide=fin_audit_wide.fillna("")

fin_audit_wide
```

Out[11]:

	Stkcd	year	Description_1	Description_2	Description_3	Method_1	Metl
0	000002	2016	存货的可变现净值的评估2016年12月31日，贵公司及其子公司(以下合称“贵集团”)已完工...	土地增值税的计提 贵集团应缴纳的主要税项之一为土地增值税。\r\n贵集团销售开发的房地产需要...	房地产开发项目的收入确认房地产开发项目的收入占贵集团2016年度营业收入总额的97%。\r...	存货的可变现净值的评估 与评价存货的可变现净值相关的审计程序中包括以下程序：\r\n1、评价...	土地 的 评价 值税 相关 程序 以下 \r\ 价管
1	000002	2017	存货的可变现净值的评估2017年12月31日，贵公司及其子公司(以下合称“贵集团”)已完工...	土地增值税的计提 贵集团应缴纳的主要税项之一为土地增值税。\r\n贵集团销售开发的房地产需要...	房地产开发项目的收入确认房地产开发项目的收入占贵集团2017年度营业收入总额的96%。\r...	存货的可变现净值的评估 与评价存货的可变现净值相关的审计程序中包括以下程序：\r\n1、评价...	土地 的 评价 值税 相关 程序 以下 \r\ 价管
2	000002	2018	存货的可变现净值的评估2018年12月31日，贵公司及其子公司(以下合称“贵集团”)已完工...	土地增值税的计提 贵集团应缴纳的主要税项之一为土地增值税。\r\n贵集团销售开发的房地产需要...	房地产开发项目的收入确认销售房地产开发项目产生的收入占贵集团2018年度营业收入总额的96...	存货的可变现净值的评估 与评价存货的可变现净值相关的审计程序中包括以下程序：\r\n1、评价...	土地 的 评价 值税 相关 程序 以下 \r\ 价管
3	000002	2019	存货的可变现净值的评估2019年12月31日，贵公司及其子公司(以下合称“贵集团”)已完工...	土地增值税的计提 贵集团应缴纳的主要税项之一为土地增值税。\r\n贵集团销售开发的房地产需要...	房地产开发项目的收入确认销售房地产开发项目产生的收入占贵集团2019年度营业收入总额的92...	存货的可变现净值的评估 与评价存货的可变现净值相关的审计程序中包括以下程序：\r\n1、评价...	土地 的 评价 值税 相关 程序 以下 \r\ 价管
4	000002	2020	存货的可变现净值的评估2020年12月31日，贵公司及其子公司(以下合称“贵集团”)已完工...	土地增值税的计提 贵集团应缴纳的主要税项之一为土地增值税。\r\n贵集团销售开发的房地产需要...	房地产开发项目的收入确认销售房地产开发项目产生的收入占贵集团2020年度营业收入总额的91...	存货的可变现净值的评估 与评价存货的可变现净值相关的审计程序中包括以下程序：\r\n1、评价...	土地 的 评价 值税 相关 程序 以下 \r\ 价管
...	...	...	...	...	...	...	...
28236	873703	2023	收入确认 广厦环能公司的营业收入主要来自于高效换热器的研发、设计、生产、销	应收账款减值 截至2023年12月31日，广厦环能公司应收账款账面余额		收入确认 针对收入确认，我们实施的审计程序主要包括：	应收 值 收 值，实 施的 序

	Stkcd	year	Description_1	Description_2	Description_3	Method_1	Metl
			售及服务。 2023...	为人民币 194,109...		\r\n(1)了解与收入确认相关的关键内...	\r\ 解与 款
28237	873706	2023	收入确认 报告期内，铁拓机械公司营业收入为41,222.90万元，铁拓机械公司向客户提供的主...			收入确认 报告期内，我们执行的审计程序主要包括：\r\n（1）了解和测试管理层与收入确认相关...	
28238	873726	2023	应收账款的可收回性 2023年12月31日，卓兆点胶合并财务报表的应收账款账面余额为10,5...	收入确认 2023年度，卓兆点胶合并财务报表确认营业收入为26,257.08万元。收入是卓兆...		应收账款的可收回性 我们实施的主要审计程序包括：\r\n1、了解、评价并测试管理层确定应收账...	收 我们 主要 序 \r\r 解、 测试 收入 关
28239	873806	2023	主营业务收入确认 星宇公司主要从事的业务为智慧交通系统集成、智慧交通技术服务、商品销售及其他...	应收账款坏账准备的计提 截至2023年12月31日，云星宇公司应收账款余额为149,000....		主营业务收入确认 我们对主营业务收入确认主要执行了以下程序：\r\n（1）了解、评价了云星宇...	应收 账准 提 应收 账准 主要 以下 \r\r 了解
28240	873833	2023	收入确认 美心翼申公司的营业收入主要来自于压缩机曲轴、通机曲轴、摩托车曲轴及配件的销售。20...	应收账款减值 截至2023年12月31日，美心翼申公司应收账款账面余额为人民币99,323,...		收入确认 针对收入确认，我们实施的审计程序主要包括：\r\n(1)了解与收入确认相关的关键内...	应收 值 收 值， 施的 序 \r\ 解与 款

28241 rows × 8 columns

In [12]:

```
string_columns = ['Description_1', 'Description_2', 'Description_3',
                  'Method_1', 'Method_2', 'Method_3']
for col in string_columns:
    fin_audit_wide[col + '_length'] = fin_audit_wide[col].astype(str).apply(len)
fin_audit_wide[[col + '_length' for col in string_columns]].describe()
fin_audit_wide[[col + '_length' for col in string_columns]].quantile(0.90)
fin_audit_wide[[col + '_length' for col in string_columns]].quantile(0.95)
```

Out[12]:

	Description_1_length	Description_2_length	Description_3_length	Method_1_
count	28241.000000	28241.000000	28241.000000	28241.
mean	225.847137	191.037534	38.389611	380.
std	116.943709	132.078689	97.177803	118.
min	20.000000	0.000000	0.000000	0.
25%	147.000000	119.000000	0.000000	305.
50%	200.000000	190.000000	0.000000	366.
75%	282.000000	272.000000	0.000000	438.
max	6807.000000	2259.000000	1795.000000	2661.

Out[12]:

```
Description_1_length    368.0
Description_2_length    360.0
Description_3_length    189.0
Method_1_length         516.0
Method_2_length         486.0
Method_3_length         290.0
Name: 0.9, dtype: float64
```

Out[12]:

```
Description_1_length    422.0
Description_2_length    399.0
Description_3_length    273.0
Method_1_length         578.0
Method_2_length         530.0
Method_3_length         375.0
Name: 0.95, dtype: float64
```

In [13]:

```
# 这里直接截取640，为快速验证代码
# 实际做的时候要考虑y, X, text的逻辑
text=fin_audit_wide.loc[:,string_columns].iloc[0:640,:]
```

In [14]:

```
text.iloc[0,0]
text.iloc[1,1]
text.iloc[0,:]
text.iloc[:,0]

# Series
type(text.iloc[0,:])
text.iloc[0,:]['Description_3']
text.iloc[0,:].iloc[0]
```

Out[14]:

'存货的可变现净值的评估 2016年12月31日，贵公司及其子公司(以下合称“贵集团”)已完工开发产品、在建开发产品及拟开发产品(以下统称“存货”)的账面价值合计金额重大。该等存货按照成本与可变现净值孰低计量。\r\n管理层确定资产负债表日每个存货项目的可变现净值。\r\n在确定存货可变现净值过程中，管理层需对每个拟开发产品和在建开发产品达到完工状态时将要发生的建造成本作出最新估计，并估算每个存货项目的预期未来净售价(参考附近地段房地产项目的最近交易价格)和未来销售费用以及相关销售税金等，该过程涉及重大的管理层判断和估计。\r\n由于存货对贵集团资产的重要性，且估计存货项目达到完工状态时将要发生的建造成本和未来净售价存在固有风险，特别是考虑到当前的经济环境在各个城市推出的各种应对房地产市场的措施，我们将对贵集团存货的可变现净值的评估识别为关键审计事项。'

Out[14]: '土地增值税的计提 贵集团应缴纳的主要税项之一为土地增值税。\r\n贵集团销售开发的房地产需要就土地增值额按照超率累进税率30%-60%缴纳土地增值税。在每个财务报告期末，管理层需要对土地增值税的计提金额进行估算，在作出估算的判断时，主要考虑的要素包括相关税务法律法规的规定和解释，预计的销售房地产取得的收入减去预计可扣除的土地成本、房地产开发成本、利息费用、开发费用等。贵集团在土地增值税汇算清缴时，实际应付税金可能与贵集团预估的金额存在差异。\r\n由于土地增值税的计提对合并财务报表的重要性，且管理层作出估计时的判断包括对相关税务法律法规和实务做法的理解等考虑要素，因此，我们将贵集团土地增值税的计提识别为关键审计事项。'

```
Out[14]: Description_1     存货的可变现净值的评估 2016年12月31日，贵公司及其子公司(以下合称“贵集团”)已完工...
Description_2     土地增值税的计提 贵集团应缴纳的主要税项之一为土地增值税。\r\n贵集团销售开发的房地产需要...
Description_3     房地产开发项目的收入确认 房地产开发项目的收入占贵集团2016年度营业收入总额的97%。\r...
Method_1          存货的可变现净值的评估 与评价存货的可变现净值相关的审计程序中包括以下程序：\r\n1、评价...
Method_2          土地增值税的计提 与评价土地增值税的计提相关的审计程序中包括以下程序：\r\n1、评价管理层...
Method_3          房地产开发项目的收入确认 与房地产开发项目的收入确认的评价相关的审计程序中包括以下程序：\r...
Name: 0, dtype: object
```

```
Out[14]: 0      存货的可变现净值的评估 2016年12月31日，贵公司及其子公司(以下合称“贵集团”)已完工...
1      存货的可变现净值的评估 2017年12月31日，贵公司及其子公司(以下合称“贵集团”)已完工...
2      存货的可变现净值的评估 2018年12月31日，贵公司及其子公司(以下合称“贵集团”)已完工...
3      存货的可变现净值的评估 2019年12月31日，贵公司及其子公司(以下合称“贵集团”)已完工...
4      存货的可变现净值的评估 2020年12月31日，贵公司及其子公司(以下合称“贵集团”)已完工...
                             ...
635    收入确认 贵公司主要从事医保基金智能管理、医疗质量安全、药械监管相关的系统研发、销售和服务。...
636    收入确认 贵公司主要从事医保基金智能管理、医疗质量安全、药械监管相关的系统研发、销售和服务。...
637    收入确认 贵公司主要从事数字医保、数字医疗、数字医院相关的系统研发、销售和服务。\r\n贵公...
638    收入确认 国新健康公司主要从事数字医保、数字医疗、数字医药相关的系统研发、销售和服务，本期营...
639    营业收入确认 南华生物公司2017年度营业收入6,739.30万元，主要为产品销售收入、工程...
Name: Description_1, Length: 640, dtype: object
```

Out[14]: pandas.core.series.Series

Out[14]: '房地产开发项目的收入确认 房地产开发项目的收入占贵集团2016年度营业收入总额的97%。\r\n贵集团在以下所有条件均已满足时确认房地产开发项目的收入：\r\n(1)与客户签署了买卖合同；\r\n(2)取得了买方的首期款并且已确认余下房款的付款安排；及\r\n(3)房产达到了买卖合同约定的交付条件。\r\n由于房地产开发项目的收入对贵集团的重要性，以及单个房地产开发项目销售收入确认上的细小错误汇总起来可能对贵集团的利润产生重大影响，因此，我们将贵集团房地产开发项目的收入确认识别为关键审计事项。'

Out[14]: '存货的可变现净值的评估 2016年12月31日，贵公司及其子公司(以下合称“贵集团”)已完工开发产品、在建开发产品及拟开发产品(以下统称“存货”)的账面价值合计金额重大。该等存货按照成本与可变现净值孰低计量。\r\n管理层确定资产负债表日每个存货项目的可变现净值。\r\n在确定存货可变现净值过程中，管理层需对每个拟开发产品和在建开发产品达到完工状态时将要发生的建造成本作出最新估计，并估算每个存货项目的预期未来净售价(参考附近地段房地产项目的最近交易价格)和未来销售费用以及相关销售税金等，该过程涉及重大的管理层判断和估计。\r\n由于存货对贵集团资产的重要性，且估计存货项目达到完工状态时将要发生的建造成本和未来净售价存在固有风险，特别是考虑到当前的经济环境在各个城市推出的各种应对房地产市场的措施，我们将对贵集团存货的可变现净值的评估识别为关键审计事项。'

编码

In [15]:
```
# 导入编码工具
from transformers import BertTokenizer
tokenizer = BertTokenizer.from_pretrained('hfl/rbt3')

# 指定计算设备，默认是GPU
import torch
device = torch.device('cuda' if torch.cuda.is_available() else "cpu")
device
```

Out[15]:
```
device(type='cuda')
```

In [16]:
```
# 测试一下数据
df=pd.DataFrame({
    "a":["这个是什么","","是呀"],
    "c":[3,6,5]
})
df
tokenizer.batch_encode_plus(batch_text_or_text_pairs=df["a"].to_list(),
    truncation=True,
    padding=True,
    max_length=10,
    return_tensors='pt')

del df
```

Out[16]:

	a	c
0	这个是什么	3
1		6
2	是呀	5

Out[16]:
```
{'input_ids': tensor([[ 101, 6821,  702, 3221,  784,  720,  102],
        [ 101,  102,    0,    0,    0,    0,    0],
        [ 101, 3221, 1435,  102,    0,    0,    0]]), 'token_type_ids': tensor
([[0, 0, 0, 0, 0, 0, 0],
        [0, 0, 0, 0, 0, 0, 0],
        [0, 0, 0, 0, 0, 0, 0]]), 'attention_mask': tensor([[1, 1, 1, 1, 1, 1,
1],
        [1, 1, 0, 0, 0, 0, 0],
        [1, 1, 1, 1, 0, 0, 0]])}
```

In [17]:
```
torch.randn(4, 3)
torch.randn(4, 2)
```

```
torch.cat((torch.randn(4, 3),torch.randn(4, 2)),dim=1)
```

```
Out[17]: tensor([[ 0.6665,  2.6763,  1.0676],
                 [-0.3586, -0.7925, -0.3186],
                 [ 0.3105, -1.7115, -0.0251],
                 [-0.8367, -0.2277,  0.4185]])
```

```
Out[17]: tensor([[-0.7470, -0.6260],
                 [ 1.2885,  0.5827],
                 [-1.0552, -0.9297],
                 [-1.0190, -0.6990]])
```

```
Out[17]: tensor([[-1.5822,  0.4336,  0.3067, -0.4456, -1.6250],
                 [ 1.3530, -1.6715, -0.9630,  0.7355, -0.1931],
                 [ 2.1584, -0.2220,  0.8866, -2.2147,  0.4675],
                 [-0.0254, -0.3842,  0.8042,  0.6267,  0.0578]])
```

```
In [18]: # 模拟演示text处理

# 将新数据添加到旧数据中，横向连接
# all_features = torch.cat((features, new_features), dim=1)
# new_dataset = TensorDataset(all_features, labels)

torch.cat((torch.randn(4, 3),torch.randn(4, 2)),dim=1)  # 两组特征放入元组
torch.cat(tuple([torch.randn(4, 3),torch.randn(4, 2)]),dim=1)  # 两组特征先进列表
# torch.cat((torch.randn(4, 3),(torch.randn(4, 3),torch.randn(4, 2))),dim=1)  #
for i in torch.utils.data.TensorDataset(torch.tensor(X), torch.tensor(y)):
    print(i)
    print(type(i))
    break

text_code = tokenizer.batch_encode_plus(batch_text_or_text_pairs=text["Method_3"
truncation=True,
padding=True,
max_length=512,
return_tensors='pt')

text_code.keys()
# dict_keys(['input_ids', 'token_type_ids', 'attention_mask'])
text_code['input_ids'].shape
text_code['token_type_ids'].shape
text_code['attention_mask'].shape
torch.cat(tuple(text_code.values()),dim=1).to(device).shape

del text_code
```

```
Out[18]: tensor([[ 0.4445, -0.3050, -0.4746,  0.6772,  0.6152],
                 [ 1.9697,  0.5271,  1.1316, -0.6730,  1.4543],
                 [-1.5906, -1.4680, -0.9359,  1.5194,  0.1675],
                 [-0.4846,  1.1095, -1.1338,  1.2833,  0.8664]])
```

```
Out[18]: tensor([[ 0.3756,  1.4494, -0.8987,  0.0111,  0.0662],
                 [ 0.7110,  1.0721, -1.7264, -0.2509, -2.2621],
                 [-1.7881,  1.0672, -0.0968,  2.0762,  1.0531],
                 [ 0.5921,  0.6612,  0.3143,  0.5428,  1.1082]])
(tensor([-1.2110, -0.3846, -0.0661,  1.0063,  0.0474, -0.6518, -0.8604, -1.6615,
        -0.5769,  0.6386], dtype=torch.float64), tensor(-143.7063, dtype=torch.fl
oat64))
<class 'tuple'>
```

```
Out[18]: dict_keys(['input_ids', 'token_type_ids', 'attention_mask'])
```

```
Out[18]: torch.Size([640, 512])
```

Out[18]: torch.Size([640, 512])

Out[18]: torch.Size([640, 512])

Out[18]: torch.Size([640, 1536])

正式封装数据

In [19]:
```
#text2code中code一列，示例
torch.randn(3, 3)
torch.randn(3, 2)
torch.cat(tuple([torch.randn(3, 3),torch.randn(3, 2)]),dim=1)
```

Out[19]:
```
tensor([[ 0.7231,  1.1927, -0.4816],
        [ 0.9879, -1.2506, -0.2710],
        [-0.5798,  0.7708,  0.3560]])
```

Out[19]:
```
tensor([[-1.1345,  0.0168],
        [-0.0443, -0.2674],
        [ 0.8340, -0.6379]])
```

Out[19]:
```
tensor([[ 0.2835, -0.4035, -1.8275, -0.5602,  0.1971],
        [-0.0202,  0.0779, -0.7745, -0.1536, -2.6290],
        [-0.2613,  0.2795,  0.8312, -0.4028,  0.5562]])
```

In [20]:
```
# 将文本六列中每一列的['input_ids', 'token_type_ids', 'attention_mask']横向合并在
def text2code(varlist):
    code=tokenizer.batch_encode_plus(batch_text_or_text_pairs=varlist,
    truncation=True,
    padding=True,
    max_length=512,
    return_tensors='pt')
    code=torch.cat(tuple(code.values()),dim=1).to(device)
    return code

string_columns = ['Description_1', 'Description_2', 'Description_3',
                  'Method_1', 'Method_2', 'Method_3']

# 验证一下
for i in string_columns:
    text2code(text[i].to_list()).shape
```

Out[20]: torch.Size([640, 1536])

Out[20]: torch.Size([640, 1536])

Out[20]: torch.Size([640, 1536])

Out[20]: torch.Size([640, 1536])

Out[20]: torch.Size([640, 1536])

Out[20]: torch.Size([640, 1536])

In [21]:
```
#函数text2code中的tokenizer.batch_encode_plus方法通常期望接收一个列表作为输入
class Dataset(torch.utils.data.Dataset):
    def __init__(self, y, X, text):
        self.y = torch.FloatTensor(y).to(device)
        self.X = torch.FloatTensor(X).to(device)
        self.Description_1 = text2code(text["Description_1"].to_list())
        self.Description_2 = text2code(text["Description_2"].to_list())
```

```
        self.Description_3 = text2code(text["Description_3"].to_list())
        self.Method_1 = text2code(text["Method_1"].to_list())
        self.Method_2 = text2code(text["Method_2"].to_list())
        self.Method_3 = text2code(text["Method_3"].to_list())

    def __len__(self):
        return len(self.y)

    def __getitem__(self, i):
        y = self.y[i]
        X = self.X[i]
        Description_1=self.Description_1[i]
        Description_2=self.Description_2[i]
        Description_3=self.Description_3[i]
        Method_1=self.Method_1[i]
        Method_2=self.Method_2[i]
        Method_3=self.Method_3[i]
        return y,X,Description_1,Description_2,Description_3,Method_1,Method_2,M

dataset = Dataset(y, X, text)
```

In [22]:
```
# 看一下数据
dataset[0]
dataset[1]
```

Out[22]:
```
(tensor(-143.7063, device='cuda:0'),
 tensor([-1.2110, -0.3846, -0.0661,  1.0063,  0.0474, -0.6518, -0.8604, -1.661
5,
         -0.5769,  0.6386], device='cuda:0'),
 tensor([ 101, 2100, 6573,  ...,    0,    0,    0], device='cuda:0'),
 tensor([ 101, 1759, 1765,  ...,    0,    0,    0], device='cuda:0'),
 tensor([ 101, 2791, 1765,  ...,    0,    0,    0], device='cuda:0'),
 tensor([ 101, 2100, 6573,  ...,    0,    0,    0], device='cuda:0'),
 tensor([ 101, 1759, 1765,  ...,    0,    0,    0], device='cuda:0'),
 tensor([ 101, 2791, 1765,  ...,    0,    0,    0], device='cuda:0'))
```

Out[22]:
```
(tensor(-31.7538, device='cuda:0'),
 tensor([ 0.5008, -0.6208,  0.6381, -0.1681, -0.5427, -1.8011, -0.7878,  2.231
3,
         -0.4721,  1.7325], device='cuda:0'),
 tensor([ 101, 2100, 6573,  ...,    0,    0,    0], device='cuda:0'),
 tensor([ 101, 1759, 1765,  ...,    0,    0,    0], device='cuda:0'),
 tensor([ 101, 2791, 1765,  ...,    0,    0,    0], device='cuda:0'),
 tensor([ 101, 2100, 6573,  ...,    0,    0,    0], device='cuda:0'),
 tensor([ 101, 1759, 1765,  ...,    0,    0,    0], device='cuda:0'),
 tensor([ 101, 2791, 1765,  ...,    0,    0,    0], device='cuda:0'))
```

In [23]:
```
len(dataset[0])
for i in range(8):
    print(dataset[0][i].shape)
#y是标量，所以没有具体size
```

Out[23]: 8

```
torch.Size([])
torch.Size([10])
torch.Size([1536])
torch.Size([1536])
torch.Size([1536])
torch.Size([1536])
torch.Size([1536])
torch.Size([1536])
```

In [24]:
```python
# 数据加载器
loader = torch.utils.data.DataLoader(
    dataset=dataset,
    batch_size=16,
    shuffle=True,
    drop_last=False,
)
# 640个样本，每批次处理量为16个，则共有40个批次
len(loader)

for i in loader:
    print(i)
    break
```

Out[24]:
```
40
```

```
[tensor([ 110.2089, -188.9447,   60.3003,   97.4888,   37.8873,   41.5269,
        -156.1774,  -18.7333,  207.7273, -153.3728,   -7.1900,  -62.2618,
         -41.5149,  108.3117,  163.7487, -675.4645], device='cuda:0'), tensor([[
0.1825,  0.4876, -0.0449,  1.1819,  1.1717, -0.6701, -1.1762,  0.2693,
          0.4809, -0.3999],
        [-1.0244, -1.4301, -3.2413, -0.4400, -1.2478, -0.2526,  1.6324, -0.0595,
          0.1307, -0.9269],
        [-0.5260, -0.8628,  0.4920,  0.6935,  1.0972, -2.1533, -0.4788,  0.4210,
         -0.3920,  0.6988],
        [ 1.2785,  0.7463,  0.0287,  0.6455,  0.0464,  0.1911, -1.3599, -0.3933,
          2.1633,  0.3687],
        [ 0.3198,  0.5525, -0.6014,  0.2239,  0.4405, -1.5930, -0.0196, -1.3340,
          1.3641,  0.1054],
        [-0.3212,  0.3687,  1.7389,  0.3938,  0.8142,  1.8326,  0.4821, -0.6356,
         -1.9277, -0.1168],
        [ 0.3993, -0.5070, -0.1753, -0.5139,  0.5043,  0.3604,  0.2910, -1.0785,
         -1.1990,  0.1072],
        [-2.4878,  0.0525, -0.1840, -0.7560,  0.9694, -0.2218, -0.6314, -0.3636,
          0.3604,  0.2912],
        [ 0.3486, -0.3849, -0.8793,  0.5409,  0.8469, -0.1252, -0.1152,  1.0719,
          0.8762,  0.4873],
        [-2.4981, -1.9496, -1.0584, -0.3508,  0.6089,  0.2005,  0.2621, -0.0611,
         -2.2183, -0.6683],
        [ 0.5536, -0.8517,  0.8579, -0.7590,  1.0821, -0.2573, -0.1290, -0.3127,
         -0.9787, -0.2087],
        [ 0.6197, -0.7588,  0.5879,  1.3509,  0.0930, -1.9113, -0.4685, -1.1863,
         -0.6537,  0.8688],
        [-0.0988,  0.1262,  0.1955, -0.2225, -2.5322,  0.4360,  0.6821,  0.5698,
          2.0469,  0.4914],
        [ 0.9716,  0.6861, -0.2490,  1.0584,  1.3686,  0.6454, -0.9649,  1.7553,
         -1.7587,  2.0607],
        [ 1.4438,  0.4568, -1.2515,  0.5698,  1.1173, -0.0822,  0.3427,  0.3521,
          0.4477, -0.2412],
        [ 0.8378, -1.2203,  0.3864, -2.0173, -2.9143, -0.6792,  0.5232, -0.5393,
         -2.8323, -1.5449]], device='cuda:0'), tensor([[ 101, 2791, 1765,  ...,
0,    0,    0],
        [ 101, 2418, 3119,  ...,    0,    0,    0],
        [ 101, 3119, 1057,  ...,    0,    0,    0],
        ...,
        [ 101, 1555, 6289,  ...,    0,    0,    0],
        [ 101, 3714, 1265,  ...,    0,    0,    0],
        [ 101, 1762, 2456,  ...,    0,    0,    0]], device='cuda:0'), tensor([[
101, 2791, 1765,  ...,    0,    0,    0],
        [ 101, 1762, 2456,  ...,    0,    0,    0],
        [ 101, 1068, 5468,  ...,    0,    0,    0],
        ...,
        [ 101, 2418, 3119,  ...,    0,    0,    0],
        [ 101, 2100, 6573,  ...,    0,    0,    0],
        [ 101, 2418,  802,  ...,    0,    0,    0]], device='cuda:0'), tensor([[
101,  102,    0,  ...,    0,    0,    0],
        [ 101,  102,    0,  ...,    0,    0,    0],
        [ 101, 7028, 1920,  ...,    0,    0,    0],
        ...,
        [ 101,  102,    0,  ...,    0,    0,    0],
        [ 101,  102,    0,  ...,    0,    0,    0],
        [ 101,  102,    0,  ...,    0,    0,    0]], device='cuda:0'), tensor([[
101, 2791, 1765,  ...,    0,    0,    0],
        [ 101, 2418, 3119,  ...,    0,    0,    0],
        [ 101, 3119, 1057,  ...,    0,    0,    0],
        ...,
```

```
        [ 101, 1555, 6289,  ...,     0,     0,     0],
        [ 101, 3714, 1265,  ...,     0,     0,     0],
        [ 101, 1762, 2456,  ...,     0,     0,     0]], device='cuda:0'), tensor([[
101, 2791, 1765,  ...,     0,     0,     0],
        [ 101, 1762, 2456,  ...,     0,     0,     0],
        [ 101, 1068, 5468,  ...,     0,     0,     0],
        ...,
        [ 101, 2418, 3119,  ...,     0,     0,     0],
        [ 101, 2100, 6573,  ...,     0,     0,     0],
        [ 101, 2418,  802,  ...,     0,     0,     0]], device='cuda:0'), tensor([[
101,  102,    0,  ...,     0,     0,     0],
        [ 101,  102,    0,  ...,     0,     0,     0],
        [ 101, 7028, 1920,  ...,     0,     0,     0],
        ...,
        [ 101,  102,    0,  ...,     0,     0,     0],
        [ 101,  102,    0,  ...,     0,     0,     0],
        [ 101,  102,    0,  ...,     0,     0,     0]], device='cuda:0')]
```

定义模型

加载预训练模型

In [25]:

```
from transformers import BertModel

# 加载预训练模型
pretrained = BertModel.from_pretrained('hfl/rbt3',cache_dir=r"C:/Users/我真是帅/
# 移动到指定设备
pretrained.to(device)

# 不训练预训练模型，不需要计算梯度
for param in pretrained.parameters():
    param.requires_grad_(False)
```

Out[25]:
```
BertModel(
  (embeddings): BertEmbeddings(
    (word_embeddings): Embedding(21128, 768, padding_idx=0)
    (position_embeddings): Embedding(512, 768)
    (token_type_embeddings): Embedding(2, 768)
    (LayerNorm): LayerNorm((768,), eps=1e-12, elementwise_affine=True)
    (dropout): Dropout(p=0.1, inplace=False)
  )
  (encoder): BertEncoder(
    (layer): ModuleList(
      (0-2): 3 x BertLayer(
        (attention): BertAttention(
          (self): BertSdpaSelfAttention(
            (query): Linear(in_features=768, out_features=768, bias=True)
            (key): Linear(in_features=768, out_features=768, bias=True)
            (value): Linear(in_features=768, out_features=768, bias=True)
            (dropout): Dropout(p=0.1, inplace=False)
          )
          (output): BertSelfOutput(
            (dense): Linear(in_features=768, out_features=768, bias=True)
            (LayerNorm): LayerNorm((768,), eps=1e-12, elementwise_affine=True)
            (dropout): Dropout(p=0.1, inplace=False)
          )
        )
        (intermediate): BertIntermediate(
          (dense): Linear(in_features=768, out_features=3072, bias=True)
          (intermediate_act_fn): GELUActivation()
        )
        (output): BertOutput(
          (dense): Linear(in_features=3072, out_features=768, bias=True)
          (LayerNorm): LayerNorm((768,), eps=1e-12, elementwise_affine=True)
          (dropout): Dropout(p=0.1, inplace=False)
        )
      )
    )
  )
  (pooler): BertPooler(
    (dense): Linear(in_features=768, out_features=768, bias=True)
    (activation): Tanh()
  )
)
```

Out[25]:
```
Parameter containing:
tensor([[ 0.0100, -0.0107, -0.0019,  ...,  0.0768,  0.0080,  0.0042],
        [ 0.0029, -0.0054,  0.0085,  ...,  0.0763,  0.0069,  0.0011],
        [ 0.0097, -0.0194, -0.0070,  ...,  0.0948, -0.0132,  0.0069],
        ...,
        [ 0.0051, -0.0100, -0.0147,  ...,  0.0768,  0.0125,  0.0177],
        [ 0.0032, -0.0148,  0.0085,  ...,  0.0702,  0.0125,  0.0033],
        [ 0.0119, -0.0067, -0.0079,  ...,  0.0783, -0.0126,  0.0058]],
       device='cuda:0')
```

Out[25]:
```
Parameter containing:
tensor([[ 0.0137,  0.0204, -0.0108,  ..., -0.1396, -0.0310, -0.0342],
        [-0.0239,  0.0140,  0.0056,  ..., -0.0480, -0.0231,  0.0640],
        [-0.0288,  0.0089, -0.0009,  ..., -0.0409,  0.0093,  0.0320],
        ...,
        [ 0.0261, -0.0244,  0.0120,  ...,  0.0781, -0.0025,  0.0214],
        [-0.0284, -0.0346, -0.0466,  ...,  0.0837, -0.0033, -0.0235],
        [ 0.0095, -0.0133, -0.0247,  ..., -0.0996, -0.0336, -0.0035]],
       device='cuda:0')
```

```
Out[25]: Parameter containing:
tensor([[-0.0022, -0.0061, -0.0068,  ...,  0.0307, -0.0034,  0.0032],
        [ 0.0061, -0.0029, -0.0048,  ...,  0.0047,  0.0029, -0.0004]],
       device='cuda:0')
```

```
Out[25]: Parameter containing:
tensor([0.9136, 0.9317, 0.9869, 0.8903, 0.3096, 0.9578, 0.8462, 0.9000, 0.8081,
        0.9004, 0.9165, 0.9091, 0.5461, 0.8489, 0.9953, 0.9011, 0.9734, 1.0004,
        0.9205, 0.8428, 1.0094, 0.8997, 0.9896, 0.8450, 0.9073, 0.9578, 0.9522,
        0.9746, 1.0049, 0.8864, 0.7389, 0.9935, 1.0244, 0.8554, 0.9541, 0.9739,
        0.8919, 0.8137, 0.8804, 0.9206, 0.9078, 0.9251, 0.9820, 0.9684, 0.8829,
        0.8929, 0.9611, 0.9561, 0.8999, 0.9109, 0.9274, 1.2068, 0.9027, 0.8365,
        0.9048, 0.9180, 0.9022, 0.9639, 0.8675, 1.0386, 0.9713, 0.9109, 0.8623,
        0.8633, 0.9782, 0.8672, 1.0071, 0.8200, 0.8706, 0.8370, 0.9302, 0.8349,
        0.9652, 0.8700, 0.9897, 0.8205, 0.9168, 0.9045, 0.2917, 0.9193, 0.9722,
        0.8534, 0.9019, 0.8538, 0.8735, 1.0128, 0.9471, 0.3258, 0.9254, 0.8085,
        0.9382, 0.8689, 0.8663, 0.8500, 0.8260, 0.7978, 0.8021, 0.9941, 0.8743,
        0.8800, 0.4010, 0.9252, 0.8126, 1.0421, 0.8643, 1.0035, 0.9386, 0.9072,
        0.8991, 0.9077, 0.9911, 0.9113, 0.9099, 0.9525, 0.8430, 0.9178, 1.0099,
        0.8634, 0.9024, 0.9124, 0.9730, 0.9828, 0.8675, 0.9438, 0.9284, 0.8660,
        0.9036, 0.8713, 0.9446, 0.9351, 0.9229, 0.8956, 0.9921, 0.9116, 0.9767,
        0.9897, 0.8737, 0.8726, 0.9350, 0.8855, 0.9386, 0.9833, 0.9516, 0.8842,
        0.8508, 0.9002, 0.9130, 0.8798, 0.9179, 0.8510, 0.9450, 0.8392, 0.8437,
        0.8980, 0.8881, 0.9194, 0.9779, 0.9726, 0.9251, 0.9828, 0.9239, 0.8782,
        0.9375, 0.9663, 0.8701, 0.9615, 0.9804, 0.8867, 0.9120, 0.8514, 0.5779,
        0.9305, 0.8635, 0.8709, 0.9593, 0.9486, 0.9898, 0.9287, 0.3702, 1.0481,
        0.9299, 1.0186, 0.9300, 0.9053, 0.7428, 0.9350, 0.8366, 0.9417, 0.3407,
        0.9160, 0.8740, 0.8558, 0.6196, 0.9318, 0.8509, 0.1594, 0.3388, 0.9381,
        0.7504, 0.9081, 0.8403, 0.9075, 1.0036, 0.9670, 0.8486, 0.9698, 0.9182,
        0.9014, 0.9043, 0.3866, 0.9814, 0.9223, 0.8818, 0.9339, 0.9748, 0.8863,
        0.9516, 0.8472, 0.8847, 0.9984, 0.8481, 0.9009, 0.9463, 0.8684, 0.9532,
        0.8509, 0.9385, 0.8811, 0.8386, 1.0169, 0.9799, 0.9252, 0.9590, 0.8602,
        0.9985, 0.9995, 0.9365, 0.8798, 0.9389, 0.9238, 0.9478, 0.2893, 0.8588,
        0.2632, 0.9044, 0.8809, 0.8627, 0.9609, 0.9720, 0.9155, 0.9467, 0.9422,
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```

Out[25]:

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        [-0.0014,  0.0413, -0.0224,  ...,  0.0395,  0.0034,  0.0406],
        ...,
        [-0.0477,  0.0195,  0.0254,  ...,  0.0491, -0.0025,  0.0338],
        [-0.0179,  0.0319,  0.0232,  ..., -0.0546,  0.0455, -0.0481],
        [ 0.0210, -0.0565,  0.0728,  ...,  0.0242, -0.0529,  0.0057]],
       device='cuda:0')
```

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Out[25]:
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        [ 0.0189, -0.0472,  0.0282,  ...,  0.0020, -0.0173, -0.0063],
        [-0.0304, -0.0220,  0.0455,  ...,  0.0141,  0.0065,  0.0111]],
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Out[25]: Parameter containing:

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          3.9083e-02,  5.6608e-02, -1.6311e-01,  1.1431e-01, -6.0088e-02,
         -5.4197e-02, -2.9643e-01, -1.0657e-02,  1.4270e-01,  1.7752e-01,
          1.1061e-01,  1.6530e-01, -6.9250e-02], device='cuda:0')
```

Out[25]:
```
Parameter containing:
tensor([[ 0.0262,  0.0069, -0.0306,  ...,  0.0125,  0.0183, -0.0239],
        [-0.0403, -0.0317, -0.0361,  ...,  0.0096, -0.0266,  0.0278],
        [ 0.0280, -0.0351,  0.0043,  ..., -0.0075, -0.0013, -0.0147],
        ...,
        [-0.0466, -0.0367,  0.1153,  ...,  0.0202, -0.0092, -0.0506],
        [-0.0392, -0.0867,  0.0300,  ...,  0.0292, -0.0075, -0.0022],
        [-0.0270, -0.0605,  0.0733,  ..., -0.0400, -0.0360, -0.0038]],
       device='cuda:0')
```

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Out[25]: Parameter containing:
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Out[25]: Parameter containing:
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```

```
Out[25]: Parameter containing:
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        [ 0.0062, -0.0730,  0.0805,  ...,  0.0274,  0.0059, -0.0150],
        [ 0.0676,  0.0338,  0.0330,  ..., -0.0077,  0.0581,  0.0194],
        ...,
        [ 0.0640, -0.0170, -0.1202,  ...,  0.0371,  0.0314, -0.0571],
        [ 0.0276, -0.0298,  0.0020,  ...,  0.0121, -0.0105,  0.0632],
        [-0.0004,  0.0175,  0.0155,  ...,  0.0765, -0.0256,  0.0484]],
       device='cuda:0')
```

```
Out[25]: Parameter containing:
tensor([-0.0615, -0.2870, -0.0031,  ..., -0.1886, -0.1573, -0.2071],
       device='cuda:0')
```

```
Out[25]: Parameter containing:
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        [ 0.0042, -0.0012, -0.0094,  ..., -0.0617, -0.0785,  0.0534],
        ...,
        [ 0.0211, -0.1127, -0.0134,  ..., -0.0470, -0.0111,  0.0117],
        [ 0.0495, -0.1157,  0.0435,  ..., -0.0301, -0.0144, -0.0261],
        [ 0.0295, -0.0128, -0.0157,  ..., -0.0643,  0.0190, -0.0234]],
       device='cuda:0')
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Out[25]:

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 1.3955e-03, -1.0734e-01,  4.2643e-02, -2.7155e-01, -1.8899e-02,
-6.3891e-02, -1.7986e-01,  6.5804e-02,  6.9659e-03, -6.0089e-02,
-2.1522e-02,  8.2923e-02, -4.2422e-03, -7.2792e-02,  3.3421e-02,
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-4.8194e-02,  6.0772e-02,  1.9259e-02,  1.2683e-01, -8.8464e-02,
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 1.1058e-01,  1.1440e-01,  1.2067e-01,  1.2137e-01, -2.1633e-01,
-6.0566e-02,  8.4888e-02, -8.8898e-03, -1.0756e-01,  1.2423e-01,
-8.1031e-02,  1.4462e-01,  7.7776e-02, -1.3824e-01,  1.1756e-01,
-2.0244e-02,  1.5942e-01,  2.8842e-01, -1.3040e-01, -2.2000e-02,
 1.4841e-02, -5.9471e-02, -4.1996e-02, -7.7772e-02,  7.9397e-02,
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-1.3956e-01, -4.0816e-02, -5.1644e-02,  1.9124e-01, -1.2841e-01,
 2.1423e-02, -3.3633e-02,  8.4053e-02, -2.0353e-02,  2.7551e-02,
-1.2884e-01,  1.3835e-02,  1.2760e-01, -5.7428e-02, -1.1205e-01,
-3.5200e-03, -4.4156e-02,  1.8028e-01, -6.9552e-02, -1.2921e-01,
-1.3792e-01,  2.2124e-01, -3.3309e-01,  8.6668e-02,  2.5192e-01,
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 1.2488e-01, -5.2274e-02,  3.7452e-03,  7.4639e-02,  3.6447e-02,
 1.1315e-01, -2.1254e-01,  4.0332e-02, -2.0574e-02,  5.6534e-02,
-5.6334e-02,  6.3822e-02,  8.4432e-02, -1.6019e-01,  4.0661e-02,
-2.7922e-01,  1.1704e-01, -3.2110e-01, -3.2016e-01,  3.4624e-02,
 1.6106e-01,  3.5885e-02, -1.8317e-01], device='cuda:0')
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Out[25]: Parameter containing:
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        0.8008, 0.7550, 0.8157, 0.7872, 0.8430, 0.7552, 0.7883, 0.8242, 0.8055,
        0.7845, 0.8441, 0.7807, 0.7278, 0.8192, 0.8587, 0.7601, 0.8079, 0.7832,
        0.7890, 0.7510, 0.7960, 0.7932, 0.8071, 0.8052, 0.8178, 0.8090, 0.7690,
        0.7675, 0.7803, 0.8026, 0.7729, 0.7886, 0.7739, 0.6954, 0.7515, 0.7729,
        0.7651, 0.7748, 0.7774, 0.7898, 0.7446, 0.8484, 0.8240, 0.7837, 0.7640,
        0.7708, 0.8294, 0.7918, 0.8013, 0.7728, 0.7498, 0.7461, 0.7631, 0.8024,
        0.8205, 0.8218, 0.8360, 0.7652, 0.7941, 0.7769, 0.6207, 0.8084, 0.7960,
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        0.7878, 0.7961, 0.7973, 0.7723, 0.7530, 0.2473, 0.7756, 0.8056, 0.7757,
        0.7544, 0.5488, 0.7639, 0.7779, 0.8371, 0.7602, 0.7491, 0.7913, 0.7737,
        0.7460, 0.7849, 0.8478, 0.7787, 0.7766, 0.7991, 0.7567, 0.7617, 0.8167,
        0.7755, 0.8052, 0.7862, 0.8236, 0.8138, 0.7887, 0.7857, 0.8127, 0.7568,
        0.7872, 0.7617, 0.8112, 0.7990, 0.8140, 0.7922, 0.7968, 0.7951, 0.7963,
        0.8111, 0.7576, 0.7800, 0.8169, 0.7577, 0.8101, 0.8438, 0.8225, 0.7930,
        0.7261, 0.7693, 0.8067, 0.8014, 0.7878, 0.8029, 0.7834, 0.7117, 0.7702,
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        0.7993, 0.7924, 0.7814, 0.8291, 0.8186, 0.7679, 0.8133, 0.7730, 0.6429,
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        0.8451, 0.7713, 0.7935, 0.8289, 0.7693, 0.7830, 0.7611, 0.8061, 0.7921,
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0.8182, 0.7323, 0.8178, 0.7929, 0.4544, 0.7227, 0.7809, 0.8016, 0.7338,
0.8107, 0.8006, 0.7748, 0.8127, 0.7923, 0.8032, 0.7705, 0.8080, 0.8147,
0.7833, 0.8001, 0.7587, 0.8130, 0.7715, 0.7516, 0.8200, 0.7145, 0.8364,
0.7458, 0.7969, 0.8171, 0.8085, 0.4231, 0.8239, 0.7794, 0.8115, 0.8223,
0.7948, 0.8124, 0.8177, 0.8082, 0.7914, 0.5212, 0.8078, 0.7764, 0.8217,
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0.8094, 0.8035, 0.8190, 0.5571, 0.4325, 0.5231, 0.7616, 0.7876, 0.7798,
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0.5516, 0.7717, 0.7794], device='cuda:0')
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Out[25]: Parameter containing:
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         2.0777e-02, -1.5310e-01,  1.7410e-02, -1.0771e-01,  1.2861e-02,
        -3.3279e-02, -6.1922e-02, -7.8879e-03,  8.4358e-02, -1.5047e-02,
        -1.7169e-02, -1.0346e-01,  3.2665e-02,  6.5431e-02, -2.0026e-01,
        -1.2132e-01,  6.4864e-02, -2.0288e-03,  1.5004e-01, -8.6924e-02,
        -2.1014e-01,  4.1615e-03, -8.9648e-03, -7.3503e-02, -1.7733e-01,
        -3.8675e-02, -5.4733e-03, -7.6872e-02,  4.1502e-02, -2.5152e-02,
        -2.5137e-02, -1.0257e-01, -1.6558e-01, -2.0213e-02,  9.3940e-02,
        -6.8714e-02, -3.3876e-01, -5.1496e-02,  5.5064e-02, -3.4882e-02,
        -2.0328e-02,  2.6670e-02, -2.3456e-02, -1.4678e-01,  2.7638e-02,
         3.5792e-03, -1.6597e-01,  3.0199e-02, -7.3764e-02, -4.6061e-02,
         8.2358e-02,  1.2623e-01, -9.9246e-02, -9.8508e-02,  2.8207e-02,
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        -1.2888e-01,  6.7204e-03,  8.9355e-02, -9.2613e-02,  8.7114e-02,
        -2.1966e-01,  8.9256e-02,  2.6957e-02, -4.9508e-02, -4.5055e-02,
        -1.3576e-01, -1.8866e-01, -1.7013e-02, -1.4942e-01,  6.1269e-02,
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         1.4079e-01, -2.7880e-02,  2.1441e-02, -7.0764e-02,  1.5329e-02,
        -6.6613e-02, -1.3893e-01, -1.3735e-01, -3.2451e-02,  4.7072e-02,
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Out[25]:

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        [ 0.0206, -0.0390,  0.0065,  ...,  0.0320, -0.0332, -0.0318],
        [ 0.0354,  0.0205, -0.0837,  ...,  0.0557,  0.0224,  0.0714],
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Out[25]:

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        [-0.0773,  0.0232,  0.0804,  ..., -0.0014,  0.0295, -0.0111],
        ...,
        [ 0.0551,  0.0015, -0.0011,  ...,  0.0400, -0.0526, -0.0602],
        [-0.0573,  0.0362, -0.0557,  ...,  0.0234,  0.0340,  0.0791],
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Out[25]:
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        ...,
        [ 0.0288, -0.0820, -0.0735,  ...,  0.0077, -0.0846,  0.0134],
        [-0.0293,  0.0061, -0.0625,  ..., -0.0200,  0.0443,  0.0792],
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Out[25]:

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         9.8569e-03,  2.1857e-01,  9.6108e-02, -2.0733e-01, -1.0376e-01,
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Out[25]:
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Parameter containing:
tensor([[-0.0057, -0.0351,  0.0090,  ..., -0.0108,  0.0596, -0.0173],
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        [-0.0301, -0.1030,  0.0362,  ...,  0.0014,  0.0294, -0.0535],
        ...,
        [-0.0560, -0.0142,  0.0597,  ..., -0.0462,  0.0234, -0.0018],
        [ 0.0303, -0.0246, -0.0103,  ..., -0.0551, -0.0067,  0.0101],
        [ 0.0263, -0.0059, -0.0464,  ...,  0.0078,  0.0493, -0.0305]],
       device='cuda:0')
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Out[25]:
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Parameter containing:
tensor([-0.1292,  0.0032, -0.1351,  ..., -0.0653, -0.0801, -0.1839],
       device='cuda:0')
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Out[25]:
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Parameter containing:
tensor([[-0.0166, -0.0513, -0.0704,  ...,  0.0246,  0.0155,  0.0596],
        [-0.0711,  0.0385,  0.0242,  ..., -0.0192,  0.0160,  0.0596],
        [ 0.0308,  0.0082,  0.0271,  ...,  0.0083,  0.0351, -0.1181],
        ...,
        [ 0.0253, -0.0202, -0.0722,  ...,  0.0670,  0.0215,  0.0229],
        [-0.0377, -0.0048, -0.0155,  ..., -0.0214, -0.0170,  0.0687],
        [-0.0176, -0.0345, -0.0149,  ...,  0.0018, -0.0085, -0.0510]],
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Out[25]: Parameter containing:
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Out[25]:
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        [-0.0105,  0.0343, -0.0060,  ..., -0.1013,  0.0116, -0.0092],
        ...,
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        [ 0.0556,  0.0283, -0.0440,  ...,  0.0046, -0.0682, -0.0016],
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       device='cuda:0')
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Out[25]:

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        ...,
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        [ 0.0238, -0.0214,  0.0053,  ..., -0.0120, -0.0422,  0.0050],
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Out[25]:
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         3.2062e-02, -3.0039e-02, -2.2624e-03,  5.1221e-02, -5.9828e-03,
         9.9458e-03,  3.2842e-02, -5.6896e-02], device='cuda:0')
```

Out[25]:
```
Parameter containing:
tensor([[-0.0028,  0.0124,  0.0399,  ...,  0.0236, -0.1044,  0.0052],
        [ 0.0392,  0.0480, -0.1074,  ...,  0.0638,  0.0313, -0.0574],
        [ 0.0059,  0.0496, -0.0081,  ...,  0.0486, -0.0150,  0.0906],
        ...,
        [-0.0451,  0.1398, -0.0124,  ..., -0.0312,  0.0836, -0.0751],
        [ 0.0031, -0.0336,  0.0217,  ...,  0.0426, -0.0454, -0.0660],
        [-0.0040, -0.0436, -0.0211,  ...,  0.1192,  0.0216, -0.0553]],
       device='cuda:0')
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        -3.4733e-03, -5.8710e-02,  1.5125e-01,  4.9130e-02,  1.4119e-01,
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         1.2672e-01, -8.3582e-02, -2.3949e-03,  3.2921e-02, -5.1044e-02,
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Out[25]: Parameter containing:
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        [ 0.0015, -0.0099, -0.0278,  ...,  0.0031,  0.0020,  0.0182],
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        [-0.0336, -0.0288, -0.0093,  ..., -0.0840, -0.0273, -0.0189],
        [-0.0236, -0.0463,  0.0808,  ...,  0.0212,  0.0136, -0.0015],
        [ 0.0075, -0.0425,  0.0781,  ..., -0.0220, -0.0015,  0.0021]],
       device='cuda:0')
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Out[25]: Parameter containing:
tensor([-0.1835, -0.0285,  0.0374,  ..., -0.0667, -0.1028, -0.0518],
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Out[25]: Parameter containing:
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        [ 0.0060, -0.0122, -0.0412,  ...,  0.0054, -0.0784,  0.0653],
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 5.8826e-02, -6.3695e-02,  3.5946e-02,  1.1572e-01, -9.9262e-03,
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-4.2930e-02,  2.2152e-02, -9.7256e-02,  2.7186e-01, -2.1299e-03,
-2.4338e-02,  1.4809e-01,  1.2092e-01, -4.7542e-02, -1.1044e-02,
-5.0733e-02, -1.5192e-01, -1.2906e-01,  7.4213e-02, -1.0915e-01,
-9.5458e-02, -1.3657e-02,  6.6633e-02, -3.0449e-02, -5.4909e-02,
-2.8366e-02,  1.7095e-01,  1.8404e-01, -3.7466e-02,  5.4094e-02,
-9.0972e-02,  8.4519e-02,  2.0529e-02,  6.6563e-02,  1.1039e-01,
-1.2394e-02,  1.0748e-01,  1.1631e-01,  1.9060e-01,  5.3941e-02,
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 1.3958e-01,  2.5005e-01, -1.7836e-01, -1.2309e-01,  5.0313e-02,
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-4.4288e-02,  5.0034e-02, -2.6185e-02, -1.0620e-01, -1.9411e-01,
-6.5164e-03, -1.5667e-01, -1.1121e-01, -2.8373e-02,  2.5031e-02,
 5.6617e-02, -1.4551e-01,  6.3255e-03, -7.5279e-02, -1.3374e-01,
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-6.3662e-02, -3.6683e-02,  2.0107e-01,  5.2064e-02, -1.9263e-01,
 6.6319e-02,  2.6481e-01,  5.5252e-03,  1.0728e-01, -3.8445e-02,
-4.9111e-03, -1.4496e-01, -9.0708e-02, -4.2051e-02,  1.2620e-02,
-2.9363e-02,  7.4038e-02, -3.0904e-01, -1.4588e-01, -1.1179e-01,
-1.9538e-02, -1.0608e-01, -8.4003e-02,  8.2158e-02, -2.1724e-01,
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-1.0211e-02, -7.7079e-02, -1.3044e-01, -1.3457e-01,  1.9357e-01,
 4.6518e-03, -6.9476e-02, -5.1692e-02, -6.7663e-02, -1.0908e-01,
-5.6892e-02,  8.4825e-02,  3.4855e-02,  1.0277e-01, -6.0358e-02,
 8.4503e-02,  3.2591e-03,  1.0939e-01,  1.3847e-01,  1.4354e-01,
 2.1572e-01, -1.9716e-02,  3.7590e-02,  1.7441e-02, -4.0748e-02,
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-1.7681e-01, -2.2996e-02,  3.5900e-02,  3.6567e-03,  2.4370e-01,
-1.0878e-01,  1.3169e-01,  6.1603e-02,  4.7538e-02,  3.3878e-02,
 1.4593e-01, -6.1482e-02,  4.8504e-02,  1.0490e-01, -1.1283e-01,
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 1.1302e-02,  5.5617e-02,  3.7498e-01,  2.4536e-02, -1.6837e-02,
-1.2400e-01, -4.3455e-02, -5.3296e-02, -1.9110e-01,  4.7941e-02,
-3.7543e-01,  2.0514e-02,  7.4793e-02,  6.1940e-02,  8.8962e-02,
-4.8476e-03,  1.4482e-01,  1.1913e-01, -1.3620e-01,  1.4721e-01,
 4.8921e-02,  1.0098e-01, -9.6508e-03,  7.4400e-02, -5.3239e-02,
 2.8332e-03, -1.1136e-01, -7.4086e-02,  1.6612e-02,  6.7475e-02,
-1.6690e-01,  5.7907e-02, -1.2344e-01, -4.5434e-02, -4.2726e-02,
 6.3707e-02,  1.0252e-01,  1.5183e-01, -8.1687e-02,  7.4977e-02,
-7.3293e-02,  7.0915e-02,  8.8456e-02,  4.1562e-02, -1.2650e-01,
-3.9583e-02, -7.7091e-02,  1.6454e-01, -3.8317e-02, -5.7675e-02,
 6.0621e-02,  1.0760e-01, -1.0047e-01,  1.4727e-01,  1.5075e-01,
-5.5545e-02,  6.8287e-02, -5.3460e-03,  2.6166e-02, -3.2041e-01,
 8.6056e-02,  2.1700e-02,  6.4507e-02,  3.3890e-02,  1.4547e-02,
 9.3661e-02, -1.4183e-01,  1.3040e-01, -1.5227e-01,  1.0561e-02,
-1.7463e-01, -5.0132e-01,  1.9306e-02, -4.5679e-02, -1.3686e-01,
-1.2724e-01,  2.0268e-01, -3.2110e-01, -3.0132e-01, -5.4694e-02,
-3.1157e-02,  9.4101e-03, -1.7494e-01], device='cuda:0')
```

```
Out[25]: Parameter containing:
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        0.7071, 0.7518, 0.7342, 0.6973, 0.7495, 0.6849, 0.6996, 0.7083, 0.7183,
        0.7155, 0.7929, 0.7000, 0.6770, 0.7263, 0.7759, 0.7354, 0.7186, 0.7231,
        0.7482, 0.7307, 0.6894, 0.7340, 0.7143, 0.7267, 0.8017, 0.7674, 0.6862,
        0.7410, 0.7315, 0.7736, 0.7029, 0.6945, 0.7104, 0.7669, 0.7408, 0.7178,
        0.7101, 0.7164, 0.7324, 0.6919, 0.7072, 0.7701, 0.7464, 0.7033, 0.6870,
        0.7335, 0.7667, 0.7086, 0.7275, 0.6839, 0.7404, 0.6934, 0.6940, 0.7065,
        0.7550, 0.7085, 0.7302, 0.7078, 0.7493, 0.7044, 0.6315, 0.7135, 0.7576,
        0.7096, 0.7069, 0.6991, 0.7203, 0.7266, 0.7323, 0.6116, 0.7460, 0.7304,
        0.7277, 0.7041, 0.6871, 0.7139, 0.6708, 0.6725, 0.6649, 0.7728, 0.7033,
        0.7502, 0.6791, 0.7065, 0.7013, 0.7608, 0.6921, 0.7510, 0.7043, 0.7130,
        0.6855, 0.7151, 0.7697, 0.6768, 0.7338, 0.7198, 0.6813, 0.7081, 0.7636,
        0.7410, 0.7959, 0.7228, 0.7186, 0.7520, 0.7301, 0.7116, 0.7160, 0.7385,
        0.7108, 0.7007, 0.6930, 0.6996, 0.7200, 0.7256, 0.7406, 0.7617, 0.7192,
        0.7248, 0.7310, 0.7305, 0.7470, 0.6933, 0.7941, 0.7795, 0.7245, 0.7361,
        0.6942, 0.7319, 0.7069, 0.7533, 0.7276, 0.7538, 0.7267, 0.6789, 0.6660,
        0.7135, 0.7111, 0.7514, 0.7231, 0.7434, 0.6991, 0.7260, 0.6972, 0.7197,
        0.7268, 0.7428, 0.7044, 0.7313, 0.7350, 0.6986, 0.7144, 0.7049, 0.6692,
        0.7352, 0.7304, 0.6980, 0.6952, 0.7533, 0.7420, 0.7253, 0.6489, 0.8120,
        0.7644, 0.7670, 0.7266, 0.7124, 0.7157, 0.7564, 0.6714, 0.7179, 0.6427,
        0.7273, 0.7073, 0.6711, 0.6691, 0.7366, 0.7231, 0.6354, 0.6690, 0.7302,
        0.6606, 0.7117, 0.7015, 0.7020, 0.7683, 0.7017, 0.7148, 0.7144, 0.7066,
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        0.6737, 0.7608, 0.6971, 0.7085, 0.7666, 0.7399, 0.7525, 0.7179, 0.6534,
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        0.6786, 0.6870, 0.7035, 0.7125, 0.7349, 0.7406, 0.7434, 0.7274, 0.7218,
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        0.6955, 0.7335, 0.7436, 0.7552, 0.7876, 0.7727, 0.7792, 0.6661, 0.7610,
        0.7161, 0.6773, 0.7837, 0.7211, 0.7177, 0.7085, 0.7353, 0.6822, 0.7822,
        0.6221, 0.7152, 0.7362, 0.7492, 0.7341, 0.7104, 0.7032, 0.7534, 0.7380,
        0.7575, 0.7191, 0.7782, 0.7424, 0.7316, 0.7150, 0.7269, 0.7028, 0.7152,
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        0.6851, 0.7296, 0.7252, 0.7379, 0.7271, 0.7034, 0.7230, 0.7121, 0.7130,
        0.7327, 0.7374, 0.7153, 0.7418, 0.7072, 0.7831, 0.7067, 0.6980, 0.7312,
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        0.7331, 0.6715, 0.7164, 0.7092, 0.7620, 0.6692, 0.6819, 0.6952, 0.7243,
        0.7302, 0.7432, 0.7387, 0.7316, 0.7460, 0.7127, 0.7717, 0.6843, 0.6998,
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        0.7458, 0.7231, 0.7693, 0.7651, 0.6786, 0.7450, 0.7089, 0.6769, 0.7202,
        0.7785, 0.7721, 0.7481, 0.7105, 0.7153, 0.7268, 0.7445, 0.7273, 0.7634,
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        0.7207, 0.7951, 0.7730, 0.6853, 0.7228, 0.7198, 0.7310, 0.8069, 0.7504,
        0.7636, 0.6986, 0.7522, 0.7543, 0.7283, 0.7390, 0.7834, 0.7266, 0.6982,
        0.8200, 0.6683, 0.7263, 0.6941, 0.6996, 0.7289, 0.7469, 0.7199, 0.7175,
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        0.6914, 0.7019, 0.7179, 0.7268, 0.7151, 0.7112, 0.7157, 0.7114, 0.7172,
        0.7578, 0.7153, 0.7222, 0.7253, 0.6848, 0.6426, 0.6501, 0.7528, 0.7297,
```

```
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0.7183, 0.7166, 0.7073, 0.7939, 0.7342, 0.7369, 0.7328, 0.7393, 0.7292,
0.7204, 0.7319, 0.7344, 0.6831, 0.6342, 0.6817, 0.6844, 0.7290, 0.7325,
0.7497, 0.7523, 0.7355, 0.7248, 0.7136, 0.7273, 0.6777, 0.7209, 0.7391,
0.7719, 0.7195, 0.7347, 0.7063, 0.7157, 0.7291, 0.7691, 0.7036, 0.7720,
0.6797, 0.7511, 0.7132, 0.7718, 0.6405, 0.7789, 0.7017, 0.7119, 0.7272,
0.7535, 0.7206, 0.7251, 0.7234, 0.7266, 0.7301, 0.7585, 0.7113, 0.7355,
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0.7071, 0.7166, 0.7132, 0.7512, 0.7124, 0.7283, 0.7187, 0.7456, 0.6563,
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0.7282, 0.7021, 0.7005, 0.7256, 0.7532, 0.7301, 0.7267, 0.7683, 0.7325,
0.7490, 0.7403, 0.7582, 0.6581, 0.6484, 0.6465, 0.7307, 0.7169, 0.7459,
0.6822, 0.7320, 0.0984, 0.7027, 0.7214, 0.7253, 0.7332, 0.7431, 0.7431,
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0.7232, 0.6973, 0.7218, 0.7227, 0.7113, 0.7225, 0.7448, 0.7025, 0.7219,
0.7613, 0.7166, 0.7489, 0.7162, 0.7444, 0.6784, 0.7441, 0.7171, 0.7295,
0.7104, 0.7365, 0.6926, 0.6930, 0.7042, 0.6972, 0.8277, 0.7433, 0.7355,
0.7485, 0.6972, 0.7301, 0.6685, 0.7416, 0.7510, 0.7427, 0.7346, 0.7065,
0.7539, 0.7274, 0.7313, 0.7173, 0.7370, 0.6912, 0.6989, 0.7077, 0.7351,
0.1386, 0.6997, 0.7189, 0.7483, 0.7132, 0.7513, 0.7188, 0.7032, 0.7137,
0.6881, 0.6834, 0.6303], device='cuda:0')
```

Out[25]: Parameter containing:

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        -5.8727e-02,  8.9936e-02, -1.9044e-02,  3.7760e-02, -2.6887e-01,
         2.2861e-03, -8.0142e-02,  1.4572e-01, -5.3427e-02,  3.9366e-02,
        -7.3666e-03, -5.8233e-02, -8.7009e-02,  6.1739e-02,  7.3810e-02,
        -3.4941e-02, -9.8284e-02, -3.8084e-02, -2.6368e-02, -1.6921e-01,
        -1.6474e-03,  5.4759e-02, -6.7397e-02,  1.6086e-02, -3.7201e-02,
        -9.6944e-02,  1.1760e-01, -9.6285e-02, -5.1656e-02, -1.6722e-01,
         4.8250e-02,  8.1764e-02, -1.2849e-01, -1.0436e-01, -8.3685e-02,
         6.0792e-02, -4.2033e-02, -6.0170e-02, -4.0768e-02,  1.0562e-01,
        -2.1032e-02, -3.1645e-01, -9.4544e-02, -1.9372e-02,  6.2067e-02,
         1.2038e-01,  7.4609e-02, -2.1464e-02, -6.6425e-02,  8.5980e-02,
        -4.1995e-02, -9.4106e-02, -1.0117e-02, -1.0520e-01, -7.8085e-03,
         1.9745e-02, -8.8574e-04, -1.4940e-01,  3.0540e-02, -7.3468e-02,
         1.1500e-01, -3.7347e-02,  9.5051e-03, -2.1573e-02,  6.4095e-03,
        -9.1370e-03,  2.4876e-02, -2.9391e-02, -1.4193e-01,  8.0722e-02,
        -1.8121e-01,  7.4251e-03, -3.1379e-02, -9.3735e-02, -4.5641e-02,
         5.0307e-02, -4.2647e-02, -5.4733e-01,  6.2220e-02, -4.9955e-02,
        -7.2482e-02,  2.9639e-02, -1.2012e-01, -9.8835e-02,  5.1734e-02,
         1.2088e-01,  3.2503e-02,  5.8041e-03, -8.3129e-02,  2.3732e-01,
        -7.5955e-02, -1.0569e-01, -4.8328e-02, -1.3952e-01, -1.5988e-01,
        -1.1636e-01, -1.5972e-01,  4.5694e-02, -7.3116e-02,  3.7835e-02,
         1.4410e-01, -5.8466e-02,  2.6799e-03,  1.0910e-02, -5.5279e-03,
         3.9544e-02, -2.0168e-02,  9.9504e-02,  1.9360e-01, -7.8285e-02,
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Out[25]:
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        ...,
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        [-0.0298,  0.0789,  0.0268,  ..., -0.0299,  0.0174,  0.0055],
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```

```
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         -6.3330e-02, -3.4405e-02, -2.0971e-02], device='cuda:0')
```

定义下游任务模型

In [27]:

```python
# 线性层特征数量
768*6+10
```

Out[27]:

```
4618
```

In [28]:

```python
# 测试取数
matrix = torch.randn(2, 9)
matrix
matrix[:,0:3]
matrix[:,3:6]
matrix[:,6:9]
```

Out[28]:

```
tensor([[-0.1789,  0.6229,  0.3913, -2.3891, -0.4337, -1.1798,  0.1729,  0.437
9,
         -2.0880],
        [ 0.5925,  0.8063, -2.7395, -0.4684, -0.3303,  0.2800, -0.1441, -0.966
5,
         -1.3249]])
```

Out[28]:

```
tensor([[-0.1789,  0.6229,  0.3913],
        [ 0.5925,  0.8063, -2.7395]])
```

Out[28]:
```
tensor([[-2.3891, -0.4337, -1.1798],
        [-0.4684, -0.3303,  0.2800]])
```

Out[28]:
```
tensor([[ 0.1729,  0.4379, -2.0880],
        [-0.1441, -0.9665, -1.3249]])
```

In [32]:
```python
# 定义下游任务模型
# loader: y,X,Description_1,Description_2,Description_3,Method_1,Method_2,Method
# 编码: 'input_ids', 'token_type_ids', 'attention_mask']
class CombinedNetwork(torch.nn.Module):
    def __init__(self):
        super().__init__()
        self.fc1 = torch.nn.Linear(4618, 1024)
        self.act1 = torch.nn.ReLU()
        self.fc2 = torch.nn.Linear(1024, 256)
        self.act2 = torch.nn.ReLU()
        self.fc3 = torch.nn.Linear(256, 1)

    def forward(
        self,
        Description_1,
        Description_2,
        Description_3,
        Method_1,
        Method_2,
        Method_3,
        tabular_data,
    ):
        # 使用预训练模型抽取数据特征
        text_D1 = pretrained(
            input_ids=Description_1[:, 0:512],
            attention_mask=Description_1[:, 1024:1536],
            token_type_ids=Description_1[:, 512:1024],
        )
        text_D2 = pretrained(
            input_ids=Description_2[:, 0:512],
            attention_mask=Description_1[:, 1024:1536],
            token_type_ids=Description_1[:, 512:1024],
        )
        text_D3 = pretrained(
            input_ids=Description_3[:, 0:512],
            attention_mask=Description_1[:, 1024:1536],
            token_type_ids=Description_1[:, 512:1024],
        )

        text_M1 = pretrained(
            input_ids=Method_1[:, 0:512],
            attention_mask=Description_1[:, 1024:1536],
            token_type_ids=Description_1[:, 512:1024],
        )
        text_M2 = pretrained(
            input_ids=Method_2[:, 0:512],
            attention_mask=Description_1[:, 1024:1536],
            token_type_ids=Description_1[:, 512:1024],
        )
        text_M3 = pretrained(
            input_ids=Method_3[:, 0:512],
            attention_mask=Description_1[:, 1024:1536],
            token_type_ids=Description_1[:, 512:1024],
        )
```

```python
        combined_features = torch.cat(
            (
                tabular_data,
                text_D1.last_hidden_state[:, 0],
                text_D2.last_hidden_state[:, 0],
                text_D3.last_hidden_state[:, 0],
                text_M1.last_hidden_state[:, 0],
                text_M2.last_hidden_state[:, 0],
                text_M3.last_hidden_state[:, 0],
            ),
            dim=1,
        )
        out = self.act1(self.fc1(combined_features))
        out = self.act2(self.fc2(out))
        out = self.fc3(out)
        return out


model = CombinedNetwork()
# 设定计算设备
model.to(device)
```

Out[32]:

```
CombinedNetwork(
  (fc1): Linear(in_features=4618, out_features=1024, bias=True)
  (act1): ReLU()
  (fc2): Linear(in_features=1024, out_features=256, bias=True)
  (act2): ReLU()
  (fc3): Linear(in_features=256, out_features=1, bias=True)
)
```

训练和评估

In [33]:

```python
# 训练
from transformers.optimization import get_scheduler
import evaluate

# loader
# y,X,Description_1,Description_2,Description_3,Method_1,Method_2,Method_3
def train():
    # 定义优化器
    optimizer = torch.optim.AdamW(model.parameters(), lr=5e-4)
    # 定义 loss 函数
    criterion = torch.nn.MSELoss()
    # 定义学习率调节器
    scheduler = get_scheduler(
        name="linear",
        num_warmup_steps=0,
        num_training_steps=len(loader),
        optimizer=optimizer,
    )
    # 将模型切换到训练模式
    model.train()
    # 按批次遍历训练集中的数据
    for i, data in enumerate(loader):
        if i >20:
            break
        # 模型计算
```

```python
        out = model(
        Description_1=data[2],
        Description_2=data[3],
        Description_3=data[4],
        Method_1=data[5],
        Method_2=data[6],
        Method_3=data[7],
        tabular_data=data[1],
        )
        # 计算loss并使用梯度下降法优化模型参数
        loss = criterion(out, data[0].unsqueeze(1))
        optimizer.zero_grad()
        loss.backward()
        optimizer.step()
        scheduler.step()

    # 按轮次计算R2
    #     with torch.no_grad():
    #         r2 = evaluate.load("r_squared")
    #         r2.add_batch(predictions=out, references=data[0].unsqueeze(1))
    # with torch.no_grad():
    #     print(r2.compute())

        # 在批次中输出R2，便于观察过程
        with torch.no_grad():
            r2 = evaluate.load("r_squared")
            result = r2.compute(predictions=out, references=data[0].unsqueeze(1)
            lr = optimizer.state_dict()["param_groups"][0]["lr"]
            print(i, loss.item(),result, lr)

train()

import evaluate
# 设置模型为评估模式
model.eval()
# 禁用梯度计算
with torch.no_grad():
    predicted = model(combined_features)  # 得到模型的输出
    predicted=predicted.squeeze(dim=1) # 移除第二个维度
    # 因为evaluate.combine有在回归任务有点问题，因此引入循环
    # 可能是mse返回dict，而r2返回标量，数据类型不一致
    for i in ["mse","r_squared"]:
        result=evaluate.load(i)
        result.compute(predictions=out, references=data[0].unsqueeze(1))
```

```
0 25243.6328125 -0.004 0.0004875
1 39575.015625 -0.014 0.000475
2 21442.859375 -0.014 0.0004625
3 31315.21484375 -0.277 0.00045000000000000004
4 11896.28125 -0.248 0.0004375
5 9334.63671875 -0.038 0.000425
6 36501.28125 -0.038 0.0004125
7 24619.984375 -0.091 0.0004
8 51342.69921875 -0.007 0.00038750000000000004
9 52586.1015625 -0.032 0.000375
10 22403.240234375 -0.085 0.0003625
11 19013.5546875 -0.193 0.00035
12 50143.015625 -0.008 0.0003375
13 75960.03125 -0.093 0.00032500000000000004
14 34534.32421875 -0.048 0.0003125
15 23440.7734375 -0.116 0.0003
16 32682.828125 -0.47 0.0002875
17 24025.5234375 -0.004 0.000275
18 22701.36328125 -0.006 0.00026250000000000004
19 21046.802734375 -0.019 0.00025
20 30709.419921875 0.001 0.0002375
```

Out[33]:

```
CombinedNetwork(
  (fc1): Linear(in_features=4618, out_features=1024, bias=True)
  (act1): ReLU()
  (fc2): Linear(in_features=1024, out_features=256, bias=True)
  (act2): ReLU()
  (fc3): Linear(in_features=256, out_features=1, bias=True)
)
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
Cell In[33], line 63
     61 # 禁用梯度计算
     62 with torch.no_grad():
---> 63     predicted = model(combined_features)  # 得到模型的输出
     64     predicted=predicted.squeeze(dim=1) # 移除第二个维度
     65     # 因为evaluate.combine有在回归任务有点问题，因此引入循环
     66     # 可能是mse返回dict，而r2返回标量，数据类型不一致

NameError: name 'combined_features' is not defined
```