# 复现报告

首先在本机上配置Anaconda+PyTorch(GPU版)+CUDA+cuDNN的代码环境,中间尽力经历了一系列版本不匹配和配置失败的问题,最后成功配置,不加赘述

clone项目到本地

阅读论文的代码文件以及readme.md文件,第一次尝试运行代码出现了OMP报错

```
OMP: Error #15: Initializing libiomp5md.dll, but found libiomp5md.dll already
initialized.
```

上网查阅资料发现可能是因为电脑的torch版本太新(2.0.1+cu118),而本项目的运行环境是torch==1.7.0+cu101,根据错误提示在main.py中加入俩行代码后成功运行

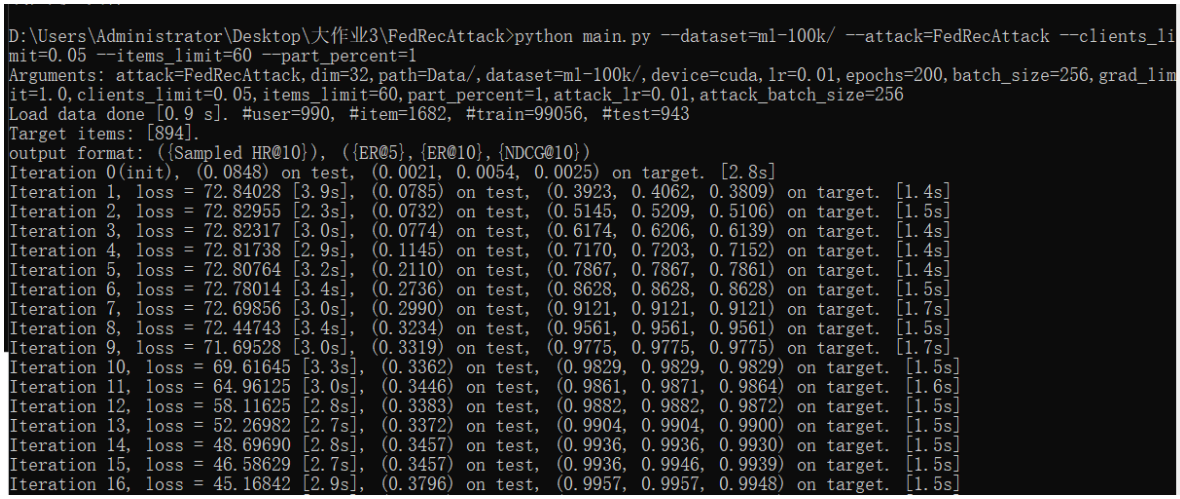
```
import os
os.environ['KMP_DUPLICATE_LIB_OK']='True'
```

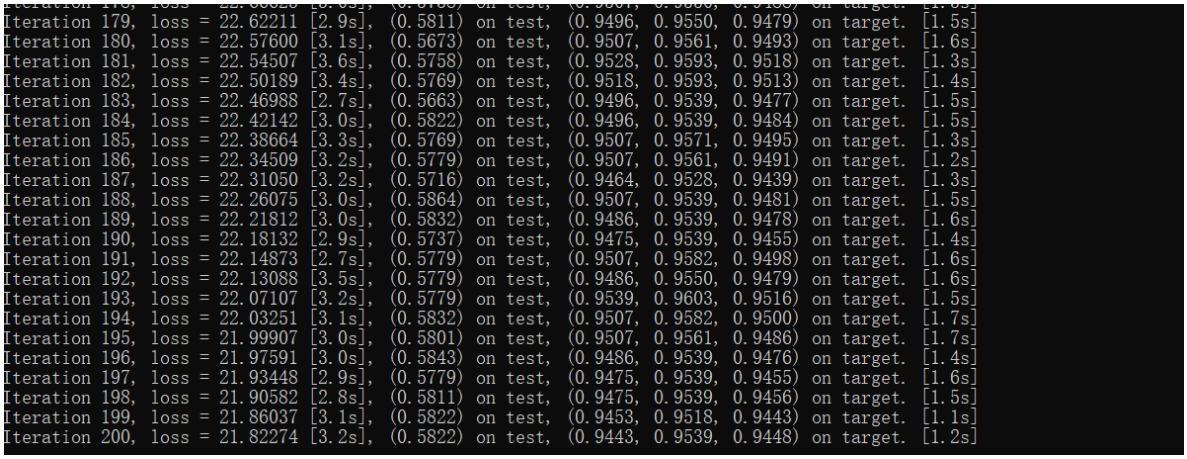
## 1.基本复现部分

按照论文内容分别在三个不同的数据集进行攻击:

ml-100数据集:

```
python main.py --dataset=ml-100k/ --attack=FedRecAttack --clients_limit=0.05 --
items_limit=60 --part_percent=1
```





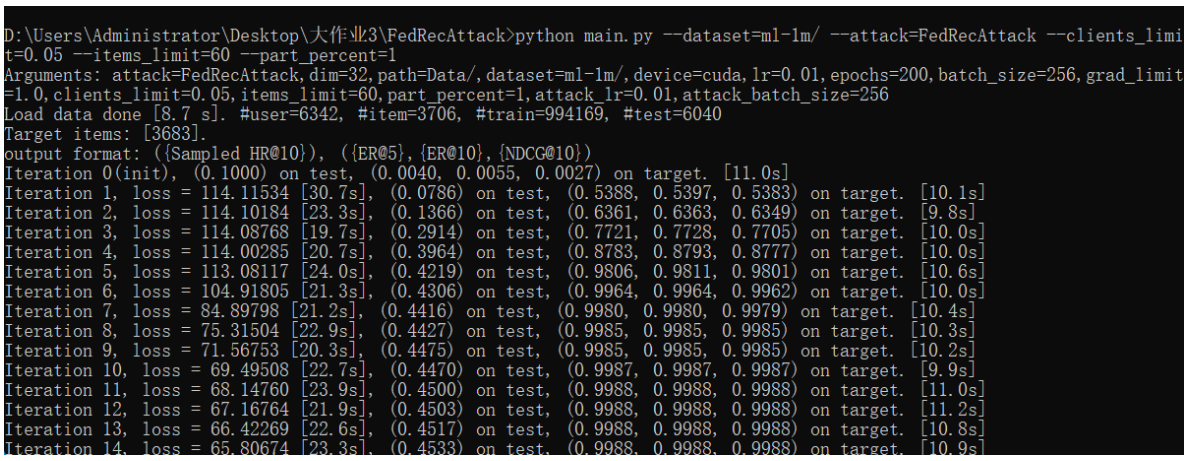

可以看到看到经过200轮攻击,对于最后一条输出结果解释如下

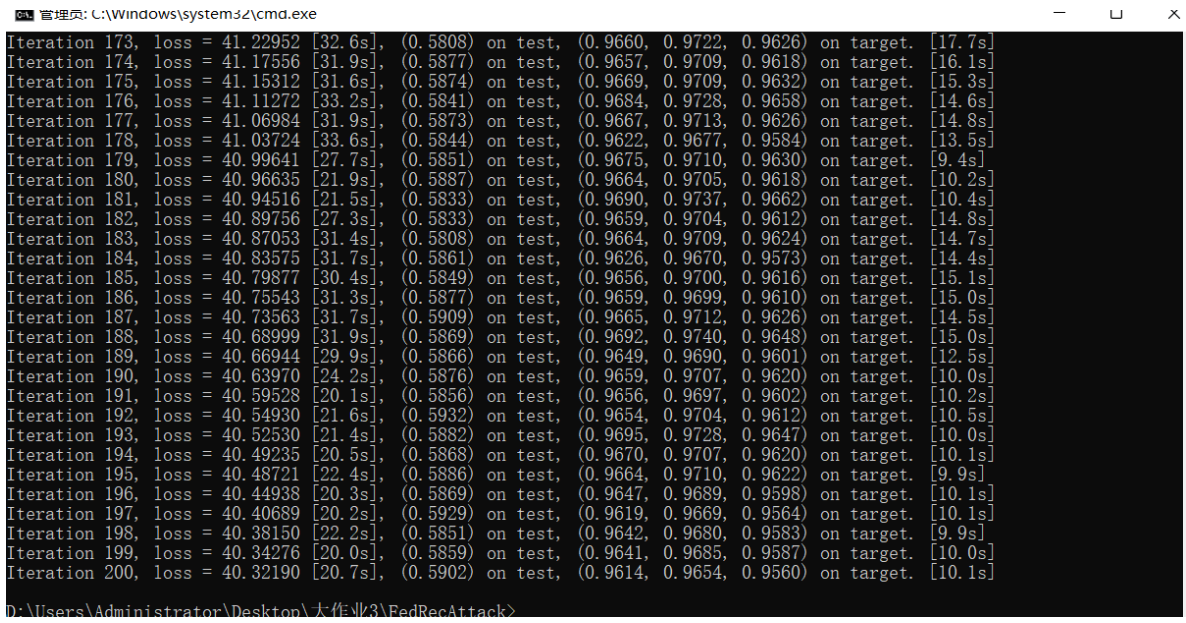
- 迭代次数：第200次迭代。
- 损失值：损失值为21.82274，表示在该次迭代中模型的训练损失。
- 测试集性能：在测试集上的性能指标为0.5822，表示在Top-K推荐中命中率为0.5822。
- 目标物品性能：性能指标有三项， ER@5和ER@10分别表示在前5，10个推荐结果中，用户实际交互的物品所占的比例。 NDCG@10表示在前10个推荐结果中，用户实际交互的物品的平均排名的归一化值，本次结果在目标物品上的性能指标分别为0.9443、0.9539和0.9448
- 总时间：整个迭代过程的运行时间为1.2秒。

这些性能指标用于评估推荐系统的效果，损失值用于衡量模型的训练效果。根据这些指标的数值，可以判断推荐系统在特定迭代中的性能和训练进展情况。

ml-1m数据集：

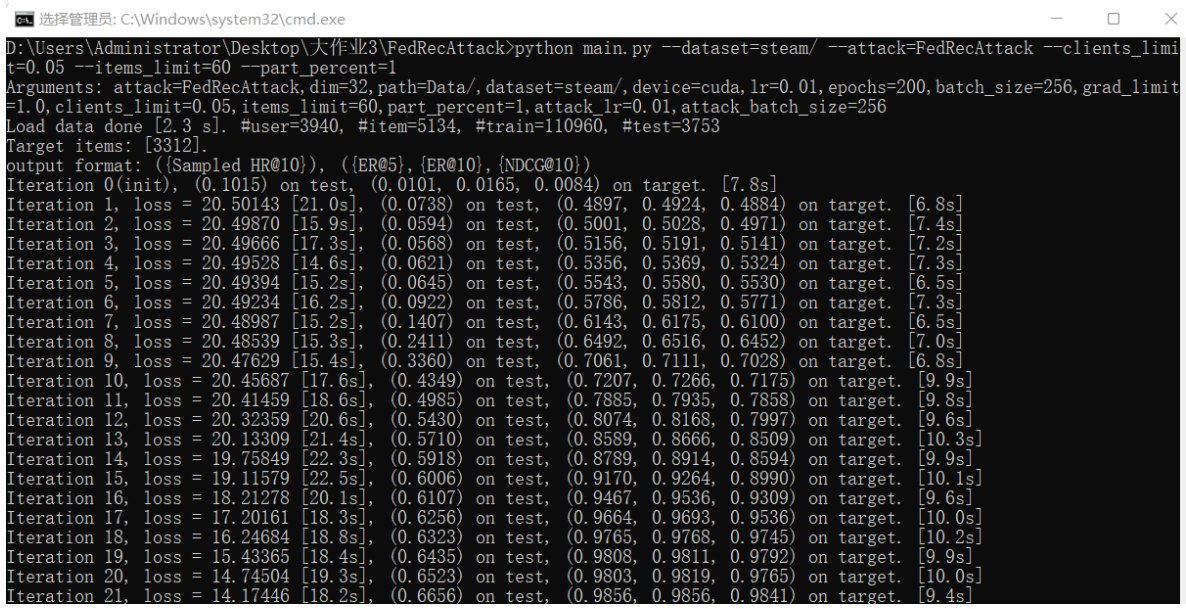
```
python main.py --dataset=ml-1m/ --attack=FedRecAttack --clients_limit=0.05 --
items_limit=60 --part_percent=1
```

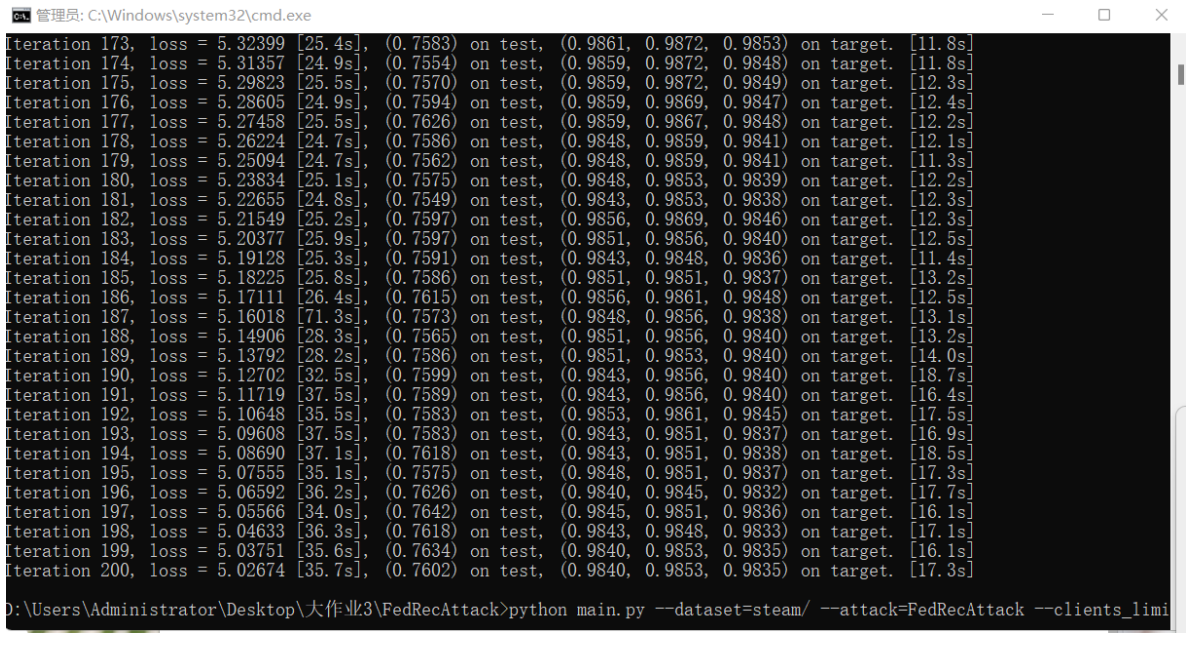





steam数据集：

```
python main.py --dataset=steam/ --attack=FedRecAttack --clients_limit=0.05 --
items_limit=60 --part_percent=1
```



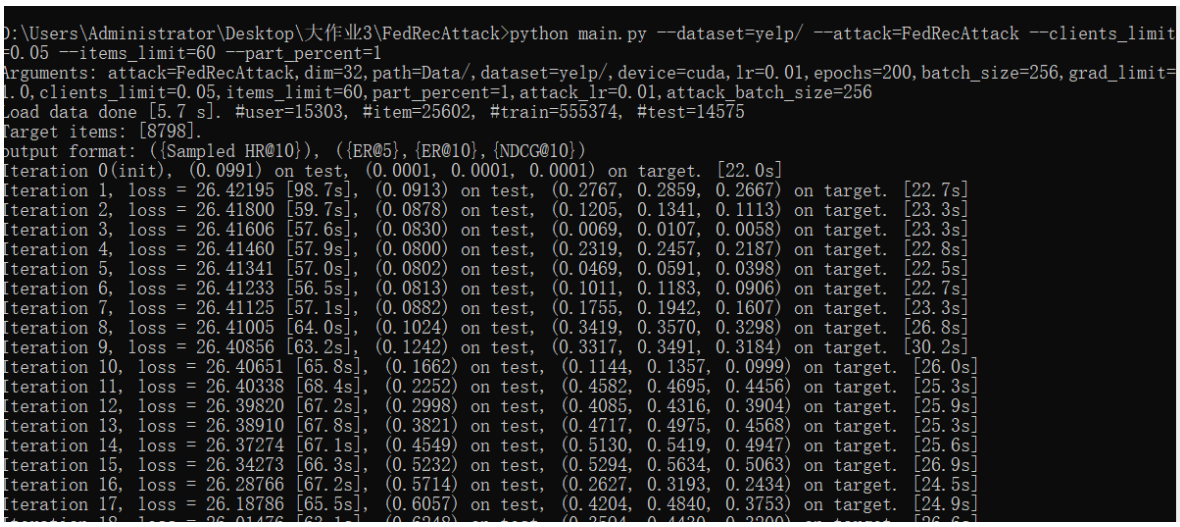



可以看到在论文的三个数据集上此攻击方法都运行成功

之后我下载了yelp数据集（Yelp Open Dataset是Yelp业务、评论和用户数据的子集），希望测试一下此方法在论文未涉及的数据集的表现。yelp数据集以json格式提供，需要转换成此方法需要的格式

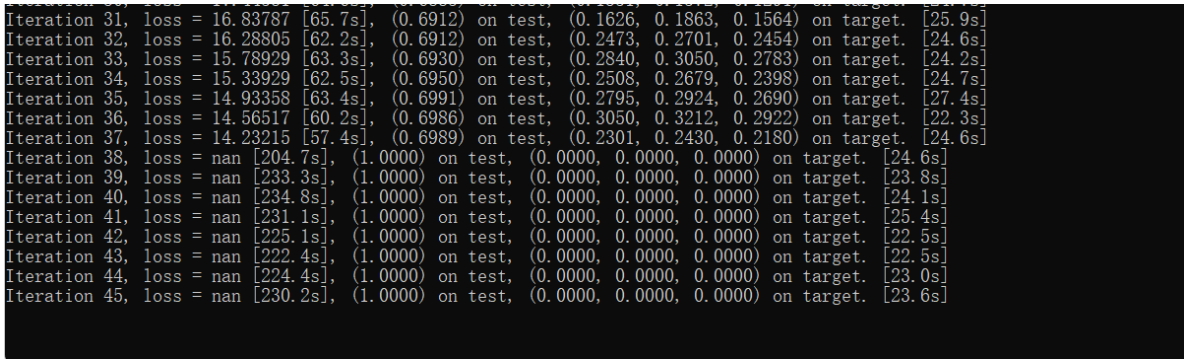
此数据集很大所以运行得非常慢：

```
python main.py --dataset=yelp/ --attack=FedRecAttack --clients_limit=0.05 --
items_limit=60 --part_percent=1
```




一开始运行良好，直到第38轮可能是攻击太强且数据集过大，模型损坏

与论文中所述数据集越密集攻击越困难这一论述相符合




## 2.对照试验部分

尝试更换参数重新训练,按照作者思路对于ml-1k数据集进行对照试验

### （1）设置part percert为不变，改变client_limit（恶意用户比例）分别为0.01，0.02，0.03，0.05，0.10，结果如表所示：

| client limit | 1% | 2% | 3% | 5% | 10% |
|---|---|---|---|---|---|
| ER@5 | 0.0011 | 0.0043 | 0.6602 | 0.9443 | 0.9475 |
| ER@10 | 0.0011 | 0.0075 | 0.717 | 0.9539 | 0.9539 |
| NDCG@10 | 0.0011 | 0.001 | 0.6380 | 0.948 | 0.9424 |

与论文中提供结果基本一致，选取5%为最佳比例

实验截图如下：

0.01：

```
D:\Users\Administrator\Desktop\大作业3\FedRecAttack>python main.py --dataset=ml-100k/ --attack=FedRecAttack --clients_li
mit=0.01 --items_limit=60 --part_percent=1
Arguments: attack=FedRecAttack, dim=32, path=Data/, dataset=ml-100k/, device=cuda, lr=0.01, epochs=200, batch_size=256, grad_lim
it=1.0, clients_limit=0.01, items_limit=60, part_percent=1, attack_lr=0.01, attack_batch_size=256
Load data done [0.9 s]. #user=952, #item=1682, #train=99056, #test=943
Target items: [894].
output format: ({Sampled HR@10}), ({ER@5}, {ER@10}, {NDCG@10})
Iteration 196, loss = 21.68017 [10.5s], (0.5832) on test, (0.0011, 0.0011, 0.0011) on target.
Iteration 197, loss = 21.64107 [11.6s], (0.5843) on test, (0.0011, 0.0011, 0.0011) on target.
Iteration 198, loss = 21.62718 [10.2s], (0.5737) on test, (0.0011, 0.0011, 0.0011) on target.
Iteration 199, loss = 21.55910 [10.8s], (0.5726) on test, (0.0011, 0.0011, 0.0011) on target.
Iteration 200, loss = 21.53680 [10.8s], (0.5960) on test, (0.0011, 0.0011, 0.0011) on target.
```

0.02

```
管理员: C:\Windows\system32\cmd.exe

D:\Users\Administrator\Desktop\大作业3\FedRecAttack>python main.py --dataset=ml-100k/ --attack=FedRecAttack --clients_li
mit=0.02 --items_limit=60 --part_percent=1
Arguments: attack=FedRecAttack, dim=32, path=Data/, dataset=ml-100k/, device=cuda, lr=0.01, epochs=200, batch_size=256, grad_lim
it=1.0, clients_limit=0.02, items_limit=60, part_percent=1, attack_lr=0.01, attack_batch_size=256
Load data done [0.9 s]. #user=961, #item=1682, #train=99056, #test=943
Target items: [894].
output format: ({Sampled HR@10}), ({ER@5}, {ER@10}, {NDCG@10})
Iteration 0(init), (0.0848) on test, (0.0021, 0.0054, 0.0025) on target. [2.2s]
Iteration 1, loss = 72.84055 [4.3s], (0.0742) on test, (0.2369, 0.2615, 0.2276) on target. [1.7s]
Iteration 2, loss = 72.82975 [3.4s], (0.0679) on test, (0.4234, 0.4352, 0.4112) on target. [1.5s]
Iteration 3, loss = 72.82205 [3.4s], (0.0710) on test, (0.5466, 0.5573, 0.5395) on target. [1.5s]
Iteration 4, loss = 72.81394 [3.0s], (0.1082) on test, (0.6710, 0.6742, 0.6673) on target. [1.6s]
Iteration 5, loss = 72.80054 [3.4s], (0.2131) on test, (0.7803, 0.7814, 0.7748) on target. [1.6s]
Iteration 6, loss = 72.76665 [3.4s], (0.2842) on test, (0.8478, 0.8478, 0.8441) on target. [1.6s]
Iteration 7, loss = 72.66980 [2.9s], (0.3192) on test, (0.9046, 0.9057, 0.9039) on target. [1.6s]
Iteration 8, loss = 72.38023 [3.7s], (0.3340) on test, (0.9528, 0.9528, 0.9515) on target. [1.6s]
Iteration 9, loss = 71.52165 [3.6s], (0.3436) on test, (0.9775, 0.9775, 0.9770) on target. [1.7s]
Iteration 10, loss = 69.19540 [3.8s], (0.3309) on test, (0.9861, 0.9861, 0.9857) on target. [1.6s]
Iteration 11, loss = 64.16395 [3.8s], (0.3309) on test, (0.4051, 0.7063, 0.3713) on target. [1.7s]
Iteration 12, loss = 57.24733 [3.7s], (0.3372) on test, (0.0129, 0.0171, 0.0125) on target. [1.8s]
Iteration 13, loss = 51.65778 [4.5s], (0.3531) on test, (0.0032, 0.0032, 0.0027) on target. [2.4s]
Iteration 14, loss = 48.29337 [5.3s], (0.3425) on test, (0.0032, 0.0032, 0.0026) on target. [2.6s]
Iteration 15, loss = 46.23841 [5.8s], (0.3542) on test, (0.0021, 0.0032, 0.0025) on target. [2.8s]
Iteration 16, loss = 44.90632 [6.1s], (0.3574) on test, (0.0000, 0.0000, 0.0000) on target. [2.8s]
Iteration 17, loss = 43.92907 [6.0s], (0.3924) on test, (0.0011, 0.0011, 0.0011) on target. [2.9s]
Iteration 18, loss = 43.21267 [5.9s], (0.3849) on test, (0.0021, 0.0021, 0.0021) on target. [2.4s]
Iteration 19, loss = 42.61553 [4.7s], (0.3733) on test, (0.0021, 0.0021, 0.0021) on target. [2.3s]
Iteration 178, loss = 22.38912 [5.0s], (0.5790) on test, (0.0021, 0.0043, 0.0028) on target. [2.5s]
Iteration 179, loss = 22.36089 [5.2s], (0.5758) on test, (0.0021, 0.0043, 0.0028) on target. [2.5s]
Iteration 180, loss = 22.32574 [4.8s], (0.5875) on test, (0.0021, 0.0043, 0.0028) on target. [2.4s]
Iteration 181, loss = 22.29192 [4.8s], (0.5769) on test, (0.0021, 0.0043, 0.0028) on target. [2.5s]
Iteration 182, loss = 22.24504 [5.3s], (0.5663) on test, (0.0021, 0.0054, 0.0031) on target. [2.5s]
Iteration 183, loss = 22.21801 [4.9s], (0.5748) on test, (0.0021, 0.0054, 0.0032) on target. [2.5s]
Iteration 184, loss = 22.16005 [4.9s], (0.5779) on test, (0.0021, 0.0054, 0.0031) on target. [2.5s]
Iteration 185, loss = 22.13547 [4.8s], (0.5875) on test, (0.0021, 0.0054, 0.0031) on target. [2.4s]
Iteration 186, loss = 22.09582 [5.2s], (0.5801) on test, (0.0021, 0.0054, 0.0032) on target. [2.5s]
Iteration 187, loss = 22.04043 [5.4s], (0.5822) on test, (0.0021, 0.0054, 0.0032) on target. [2.5s]
Iteration 188, loss = 22.02274 [5.0s], (0.5695) on test, (0.0032, 0.0054, 0.0033) on target. [2.5s]
Iteration 189, loss = 21.98285 [4.6s], (0.5822) on test, (0.0032, 0.0054, 0.0033) on target. [2.4s]
Iteration 190, loss = 21.95585 [5.5s], (0.5748) on test, (0.0032, 0.0064, 0.0036) on target. [2.5s]
Iteration 191, loss = 21.89178 [4.5s], (0.5779) on test, (0.0032, 0.0054, 0.0033) on target. [2.5s]
Iteration 192, loss = 21.86089 [4.7s], (0.5801) on test, (0.0032, 0.0054, 0.0033) on target. [2.5s]
Iteration 193, loss = 21.82058 [4.9s], (0.5811) on test, (0.0032, 0.0064, 0.0036) on target. [2.5s]
Iteration 194, loss = 21.79967 [5.6s], (0.5790) on test, (0.0032, 0.0064, 0.0037) on target. [2.5s]
Iteration 195, loss = 21.75558 [5.1s], (0.5716) on test, (0.0032, 0.0064, 0.0036) on target. [2.4s]
Iteration 196, loss = 21.72111 [4.8s], (0.5589) on test, (0.0043, 0.0075, 0.0041) on target. [2.5s]
Iteration 197, loss = 21.67985 [4.9s], (0.5790) on test, (0.0043, 0.0075, 0.0041) on target. [2.4s]
Iteration 198, loss = 21.64073 [5.1s], (0.5822) on test, (0.0043, 0.0075, 0.0041) on target. [2.6s]
Iteration 199, loss = 21.62256 [4.7s], (0.5779) on test, (0.0032, 0.0075, 0.0040) on target. [2.4s]
Iteration 200, loss = 21.57138 [4.4s], (0.5695) on test, (0.0043, 0.0075, 0.0041) on target. [2.5s]
```

0.03：

```
D:\Users\Administrator\Desktop\大作业3\FedRecAttack>python main.py --dataset=ml-100k/ --attack=FedRecAttack --clients_li
mit=0.03 --items_limit=60 --part_percent=1
Arguments: attack=FedRecAttack, dim=32, path=Data/, dataset=ml-100k/, device=cuda, lr=0.01, epochs=200, batch_size=256, grad_lim
it=1.0, clients_limit=0.03, items_limit=60, part_percent=1, attack_lr=0.01, attack_batch_size=256
Load data done [1.4 s]. #user=971, #item=1682, #train=99056, #test=943
Target items: [894].
output format: ({Sampled HR@10}), ({ER@5}, {ER@10}, {NDCG@10})
Iteration 0(init), (0.0848) on test, (0.0021, 0.0054, 0.0025) on target. [3.5s]
Iteration 1, loss = 72.84042 [5.3s], (0.0774) on test, (0.3237, 0.3387, 0.3119) on target. [1.9s]
Iteration 196, loss = 21.73717 [9.6s], (0.5716) on test, (0.6484, 0.6999, 0.6256) on target. [3.8s]
Iteration 197, loss = 21.69068 [8.5s], (0.5864) on test, (0.6517, 0.7010, 0.6256) on target. [4.0s]
Iteration 198, loss = 21.64971 [8.8s], (0.5790) on test, (0.6602, 0.7095, 0.6335) on target. [3.9s]
Iteration 199, loss = 21.63022 [8.8s], (0.5726) on test, (0.6581, 0.7149, 0.6385) on target. [3.9s]
Iteration 200, loss = 21.58924 [9.5s], (0.5822) on test, (0.6602, 0.7170, 0.6380) on target. [3.9s]
```

0.1

```
D:\Users\Administrator\Desktop\大作业3\FedRecAttack>python main.py --dataset=ml-100k/ --attack=FedRecAttack --clients_li
mit=0.1 --items_limit=60 --part_percent=1
Arguments: attack=FedRecAttack, dim=32, path=Data/, dataset=ml-100k/, device=cuda, lr=0.01, epochs=200, batch_size=256, grad_lim
it=1.0, clients_limit=0.1, items_limit=60, part_percent=1, attack_lr=0.01, attack_batch_size=256
Load data done [1.4 s]. #user=1037, #item=1682, #train=99056, #test=943
Target items: [894].
output format: ({Sampled HR@10}), ({ER@5}, {ER@10}, {NDCG@10})
Iteration 0(init), (0.0848) on test, (0.0021, 0.0054, 0.0025) on target. [4.5s]
Iteration 1, loss = 72.84017 [8.3s], (0.0742) on test, (0.3934, 0.4062, 0.3828) on target. [2.4s]
```

```
Iteration 193, loss = 22.10274 [7.2s], (0.5843) on test, (0.9443, 0.9528, 0.9399) on target. [3.5s]
Iteration 194, loss = 22.05673 [8.0s], (0.5673) on test, (0.9486, 0.9539, 0.9421) on target. [3.5s]
Iteration 195, loss = 22.00807 [7.1s], (0.5864) on test, (0.9443, 0.9518, 0.9401) on target. [3.4s]
Iteration 196, loss = 21.98966 [7.6s], (0.5832) on test, (0.9389, 0.9507, 0.9389) on target. [3.5s]
Iteration 197, loss = 21.94604 [8.0s], (0.5748) on test, (0.9432, 0.9518, 0.9380) on target. [3.5s]
Iteration 198, loss = 21.92409 [7.7s], (0.5779) on test, (0.9518, 0.9582, 0.9481) on target. [3.5s]
Iteration 199, loss = 21.88342 [7.4s], (0.5896) on test, (0.9486, 0.9582, 0.9463) on target. [3.5s]
Iteration 200, loss = 21.84087 [8.2s], (0.5843) on test, (0.9475, 0.9539, 0.9424) on target. [3.5s]
```

## （2）设置client_limit为不变，改变part_percert（公共互动比例）分别为0.01，0.02，0.03，0.05，0.10，结果如表所示：

| part percent | 1% | 2% | 3% | 5% | 10% |
|---|---|---|---|---|---|
| ER@5 | 0.9443 | 0.9786 | 0.9882 | 0.9914 | 0.9807 |
| ER@10 | 0.9539 | 0.9861 | 0.9893 | 0.9946 | 0.9861 |
| NDCG@10 | 0.9448 | 0.9772 | 0.9846 | 0.9887 | 0.9809 |

与论文结果基本一致，取最佳比例为5%

实验截图如下：

2%：

```
D:\Users\Administrator\Desktop\大作业3\FedRecAttack>python main.py --dataset=ml-100k/ --attack=FedRecAttack --clients_li
mit=0.05 --items_limit=60 --part_percent=2
Arguments: attack=FedRecAttack, dim=32, path=Data/, dataset=ml-100k/, device=cuda, lr=0.01, epochs=200, batch_size=256, grad_lim
it=1.0, clients_limit=0.05, items_limit=60, part_percent=2, attack_lr=0.01, attack_batch_size=256
Load data done [1.7 s]. #user=990, #item=1682, #train=99056, #test=943
Target items: [894].
output format: ({Sampled HR@10}), ({ER@5}, {ER@10}, {NDCG@10})
Iteration 0(init), (0.0848) on test, (0.0021, 0.0054, 0.0025) on target. [5.4s]
Iteration 1, loss = 72.84027 [9.6s], (0.0742) on test, (0.3912, 0.3976, 0.3788) on target. [3.1s]
```

```
Iteration 197, loss = 22.03341 [6.1s], (0.5811) on test, (0.9807, 0.9850, 0.9785) on target. [2.9s]
Iteration 198, loss = 21.98507 [6.4s], (0.5790) on test, (0.9839, 0.9882, 0.9802) on target. [2.9s]
Iteration 199, loss = 21.94500 [5.9s], (0.5949) on test, (0.9796, 0.9861, 0.9772) on target. [3.0s]
Iteration 200, loss = 21.90386 [6.2s], (0.5875) on test, (0.9786, 0.9861, 0.9772) on target. [3.0s]
```

3%

```
D:\Users\Administrator\Desktop\大作业3\FedRecAttack>python main.py --dataset=ml-100k/ --attack=FedRecAttack --clients_li
mit=0.05 --items_limit=60 --part_percent=3
Arguments: attack=FedRecAttack, dim=32, path=Data/, dataset=ml-100k/, device=cuda, lr=0.01, epochs=200, batch_size=256, grad_lim
it=1.0, clients_limit=0.05, items_limit=60, part_percent=3, attack_lr=0.01, attack_batch_size=256
Load data done [2.0 s]. #user=990, #item=1682, #train=99056, #test=943
Target items: [894].
output format: ({Sampled HR@10}), ({ER@5}, {ER@10}, {NDCG@10})
Iteration 0(init), (0.0848) on test, (0.0021, 0.0054, 0.0025) on target. [7.2s]
Iteration 1, loss = 72.84026 [12.9s], (0.0732) on test, (0.3773, 0.3891, 0.3711) on target. [5.0s]
Iteration 196, loss = 22.19873 [5.0s], (0.5748) on test, (0.9871, 0.9893, 0.9835) on target. [2.7s]
Iteration 197, loss = 22.17423 [5.1s], (0.5769) on test, (0.9893, 0.9904, 0.9853) on target. [2.4s]
Iteration 198, loss = 22.13286 [4.9s], (0.5673) on test, (0.9861, 0.9882, 0.9839) on target. [2.4s]
Iteration 199, loss = 22.11574 [5.2s], (0.5875) on test, (0.9882, 0.9893, 0.9851) on target. [2.4s]
Iteration 200, loss = 22.07910 [4.9s], (0.5726) on test, (0.9882, 0.9893, 0.9846) on target. [2.6s]
```

5%

```
D:\Users\Administrator\Desktop\大作业3\FedRecAttack>python main.py --dataset=ml-100k/ --attack=FedRecAttack --clients_li
mit=0.05 --items_limit=60 --part_percent=5
Arguments: attack=FedRecAttack, dim=32, path=Data/, dataset=ml-100k/, device=cuda, lr=0.01, epochs=200, batch_size=256, grad_lim
it=1.0, clients_limit=0.05, items_limit=60, part_percent=5, attack_lr=0.01, attack_batch_size=256
Load data done [2.8 s]. #user=990, #item=1682, #train=99056, #test=943
Target items: [894].
output format: ({Sampled HR@10}), ({ER@5}, {ER@10}, {NDCG@10})
Iteration 0(init), (0.0848) on test, (0.0021, 0.0054, 0.0025) on target. [11.4s]
Iteration 1, loss = 72.84029 [20.5s], (0.0817) on test, (0.4019, 0.4202, 0.3973) on target. [5.2s]
```

```
Iteration 196, loss = 22.30896 [4.0s], (0.5801) on test, (0.9882, 0.9946, 0.9884) on target. [1.6s]
Iteration 197, loss = 22.29452 [4.5s], (0.5854) on test, (0.9882, 0.9936, 0.9876) on target. [1.8s]
Iteration 198, loss = 22.25793 [4.0s], (0.5822) on test, (0.9904, 0.9936, 0.9888) on target. [1.6s]
Iteration 199, loss = 22.22527 [3.8s], (0.5737) on test, (0.9904, 0.9936, 0.9878) on target. [1.7s]
Iteration 200, loss = 22.18094 [2.8s], (0.5726) on test, (0.9914, 0.9946, 0.9887) on target. [1.3s]
```

10%

```
D:\Users\Administrator\Desktop\大作业3\FedRecAttack>python main.py --dataset=ml-100k/ --attack=FedRecAttack --clients_li
mit=0.05 --items_limit=60 --part_percent=10
Arguments: attack=FedRecAttack, dim=32, path=Data/, dataset=ml-100k/, device=cuda, lr=0.01, epochs=200, batch_size=256, grad_lim
it=1.0, clients_limit=0.05, items_limit=60, part_percent=10, attack_lr=0.01, attack_batch_size=256
Load data done [2.9 s]. #user=990, #item=1682, #train=99056, #test=943
Target items: [894].
output format: ({Sampled HR@10}), ({ER@5}, {ER@10}, {NDCG@10})
Iteration 0(init), (0.0848) on test, (0.0021, 0.0054, 0.0025) on target. [15.4s]
Iteration 1, loss = 72.84032 [24.9s], (0.0732) on test, (0.4062, 0.4191, 0.3963) on target. [5.4s]
Iteration 197, loss = 22.34182 [4.2s], (0.5769) on test, (0.9786, 0.9839, 0.9788) on target. [1.6s]
Iteration 198, loss = 22.29743 [3.9s], (0.5801) on test, (0.9818, 0.9861, 0.9803) on target. [1.7s]
Iteration 199, loss = 22.24665 [4.5s], (0.5832) on test, (0.9807, 0.9850, 0.9794) on target. [1.6s]
Iteration 200, loss = 22.22613 [4.1s], (0.5695) on test, (0.9807, 0.9861, 0.9809) on target. [1.7s]
```

# 3.与其他方法作对比

参数规定:clients_limit = 0.05  part_percent = 1,测试论文提供的攻击方法Random,Bandwagon和Popular与FedRecAttack的性能差异:

| method(clients_limit = 0.05) | FedRecAttack | Random | Bandwagon | Popular |
|---|---|---|---|---|
| ER@5 | 0.9443 | 0.000 | 0.000 | 0.0011 |
| ER@10 | 0.9539 | 0.000 | 0.000 | 0.0011 |
| NDCG@10 | 0.9448 | 0.000 | 0.000 | 0.0011 |

FedRecAttack性能远强于其余三个方法

因为性能指标太小,适当调大恶意用户比例再进行测试,这里调整参数clients_limit = 0.1  part_percent = 1;

| method(clients_limit = 0.1) | FedRecAttack | Random | Bandwagon | Popular |
|---|---|---|---|---|
| ER@5 | 0.9475 | 0.0011 | 0.000 | 0.0032 |
| ER@10 | 0.9539 | 0.0011 | 0.000 | 0.0075 |
| NDCG@10 | 0.9424 | 0.005 | 0.000 | 0.0033 |

实验截图如下

Random:0.05

```
D:\Users\Administrator\Desktop\大作业3\FedRecAttack>python main.py --dataset=ml-100k/ --attack=Random --clients_limit=0.
05 --items_limit=60 --part_percent=1
Arguments: attack=Random, dim=32, path=Data/, dataset=ml-100k/, device=cuda, lr=0.01, epochs=200, batch_size=256, grad_limit=1.0
, clients_limit=0.05, items_limit=60, part_percent=1, attack_lr=0.01, attack_batch_size=256
Load data done [1.1 s]. #user=990, #item=1682, #train=99056, #test=943
Target items: [894].
output format: ({Sampled HR@10}), ({ER@5}, {ER@10}, {NDCG@10})
Iteration 0(init), (0.0891) on test, (0.0021, 0.0054, 0.0025) on target. [2.1s]
Iteration 1, loss = 72.84071 [2.5s], (0.0689) on test, (0.0043, 0.0054, 0.0029) on target. [1.0s]
```

```
Iteration 196, loss = 21.64610 [4.8s], (0.5801) on test, (0.0000, 0.0000, 0.0000) on target. [2.5s]
Iteration 197, loss = 21.60145 [5.4s], (0.5758) on test, (0.0000, 0.0000, 0.0000) on target. [2.6s]
Iteration 198, loss = 21.56985 [5.3s], (0.5885) on test, (0.0000, 0.0000, 0.0000) on target. [2.5s]
Iteration 199, loss = 21.53751 [4.6s], (0.5779) on test, (0.0000, 0.0000, 0.0000) on target. [2.6s]
Iteration 200, loss = 21.51632 [4.8s], (0.5811) on test, (0.0000, 0.0000, 0.0000) on target. [2.7s]
```

Random:0.1

```
D:\Users\Administrator\Desktop\大作业3\FedRecAttack>python main.py --dataset=ml-100k/ --attack=Random --clients_limit=0.
1 --items_limit=60 --part_percent=1
Arguments: attack=Random,dim=32,path=Data/,dataset=ml-100k/,device=cuda,lr=0.01,epochs=200,batch_size=256,grad_limit=1.0
,clients_limit=0.1,items_limit=60,part_percent=1,attack_lr=0.01,attack_batch_size=256
Load data done [0.9 s]. #user=1037, #item=1682, #train=99056, #test=943
Target items: [894].
output format: ({Sampled HR@10}), ({ER@5},{ER@10},{NDCG@10})
Iteration 0(init), (0.0870) on test, (0.0021, 0.0054, 0.0025) on target. [2.0s]
Iteration 1, loss = 72.84068 [2.4s], (0.0700) on test, (0.0043, 0.0054, 0.0027) on target. [1.0s]
```

```
Iteration 196, loss = 21.67303 [8.5s], (0.5970) on test, (0.0011, 0.0011, 0.0005) on target. [4.1s]
Iteration 197, loss = 21.61880 [8.0s], (0.5885) on test, (0.0011, 0.0011, 0.0004) on target. [4.0s]
Iteration 198, loss = 21.58230 [7.6s], (0.5748) on test, (0.0011, 0.0011, 0.0005) on target. [4.1s]
Iteration 199, loss = 21.53650 [8.5s], (0.5875) on test, (0.0011, 0.0011, 0.0005) on target. [4.2s]
Iteration 200, loss = 21.50799 [8.3s], (0.5854) on test, (0.0011, 0.0011, 0.0005) on target. [4.1s]
```

Bandwagon:0.05

```
D:\Users\Administrator\Desktop\大作业3\FedRecAttack>python main.py --dataset=ml-100k/ --attack=Bandwagon --clients_limit
=0.05 --items_limit=60 --part_percent=1
Arguments: attack=Bandwagon,dim=32,path=Data/,dataset=ml-100k/,device=cuda,lr=0.01,epochs=200,batch_size=256,grad_limit=
1.0,clients_limit=0.05,items_limit=60,part_percent=1,attack_lr=0.01,attack_batch_size=256
Load data done [1.2 s]. #user=990, #item=1682, #train=99056, #test=943
Target items: [894].
output format: ({Sampled HR@10}), ({ER@5},{ER@10},{NDCG@10})
Iteration 0(init), (0.0933) on test, (0.0021, 0.0054, 0.0025) on target. [3.8s]
Iteration 1, loss = 72.84073 [3.5s], (0.0700) on test, (0.0043, 0.0054, 0.0029) on target. [1.8s]
```

```
Iteration 197, loss = 21.61573 [4.1s], (0.5705) on test, (0.0000, 0.0000, 0.0000) on target. [1.9s]
Iteration 198, loss = 21.56709 [3.7s], (0.5769) on test, (0.0000, 0.0000, 0.0000) on target. [1.9s]
Iteration 199, loss = 21.54826 [4.0s], (0.5790) on test, (0.0000, 0.0000, 0.0000) on target. [2.0s]
Iteration 200, loss = 21.50386 [3.7s], (0.5970) on test, (0.0000, 0.0000, 0.0000) on target. [1.9s]
```

Bandwagon:0.1

```
D:\Users\Administrator\Desktop\大作业3\FedRecAttack>python main.py --dataset=ml-100k/ --attack=Bandwagon --clients_limit
=0.1 --items_limit=60 --part_percent=1
Arguments: attack=Bandwagon,dim=32,path=Data/,dataset=ml-100k/,device=cuda,lr=0.01,epochs=200,batch_size=256,grad_limit=
1.0,clients_limit=0.1,items_limit=60,part_percent=1,attack_lr=0.01,attack_batch_size=256
Load data done [1.2 s]. #user=1037, #item=1682, #train=99056, #test=943
Target items: [894].
output format: ({Sampled HR@10}), ({ER@5},{ER@10},{NDCG@10})
Iteration 0(init), (0.0870) on test, (0.0021, 0.0054, 0.0025) on target. [3.3s]
Iteration 1, loss = 72.84069 [3.8s], (0.0817) on test, (0.0043, 0.0054, 0.0028) on target. [2.0s]
Iteration 196, loss = 21.68057 [8.3s], (0.5801) on test, (0.0000, 0.0000, 0.0000) on target. [4.4s]
Iteration 197, loss = 21.62651 [8.1s], (0.5769) on test, (0.0000, 0.0000, 0.0000) on target. [4.6s]
Iteration 198, loss = 21.61202 [7.9s], (0.5811) on test, (0.0000, 0.0011, 0.0003) on target. [3.2s]
Iteration 199, loss = 21.56540 [6.0s], (0.5822) on test, (0.0000, 0.0011, 0.0003) on target. [3.0s]
Iteration 200, loss = 21.53406 [6.3s], (0.5864) on test, (0.0000, 0.0000, 0.0000) on target. [3.0s]
```

Popular:0.05

```
D:\Users\Administrator\Desktop\大作业3\FedRecAttack>python main.py --dataset=ml-100k/ --attack=Popular --clients_limit=0
.05 --items_limit=60 --part_percent=1
Arguments: attack=Popular,dim=32,path=Data/,dataset=ml-100k/,device=cuda,lr=0.01,epochs=200,batch_size=256,grad_limit=1.
0,clients_limit=0.05,items_limit=60,part_percent=1,attack_lr=0.01,attack_batch_size=256
Load data done [1.5 s]. #user=990, #item=1682, #train=99056, #test=943
Target items: [894].
output format: ({Sampled HR@10}), ({ER@5},{ER@10},{NDCG@10})
Iteration 0(init), (0.0923) on test, (0.0021, 0.0054, 0.0025) on target. [3.9s]
Iteration 1, loss = 72.84071 [4.3s], (0.0679) on test, (0.0043, 0.0054, 0.0029) on target. [2.3s]
```

```
Iteration 197, loss = 21.62055 [2.7s], (0.5811) on test, (0.0011, 0.0011, 0.0011) on target. [1.5s]
Iteration 198, loss = 21.59166 [2.8s], (0.5748) on test, (0.0011, 0.0011, 0.0011) on target. [1.5s]
Iteration 199, loss = 21.54119 [3.0s], (0.5769) on test, (0.0011, 0.0011, 0.0011) on target. [1.6s]
Iteration 200, loss = 21.52357 [3.2s], (0.5864) on test, (0.0011, 0.0011, 0.0011) on target. [1.5s]
```

Popular:0.1

```
D:\Users\Administrator\Desktop\大作业3\FedRecAttack>python main.py --dataset=ml-100k/ --attack=Bandwagon --clients_limit
=0.1 --items_limit=60 --part_percent=1
Arguments: attack=Bandwagon,dim=32,path=Data/,dataset=ml-100k/,device=cuda,lr=0.01,epochs=200,batch_size=256,grad_limit=
1.0,clients_limit=0.1,items_limit=60,part_percent=1,attack_lr=0.01,attack_batch_size=256
Load data done [1.2 s]. #user=1037, #item=1682, #train=99056, #test=943
Target items: [894].
output format: ({Sampled HR@10}), ({ER@5},{ER@10},{NDCG@10})
Iteration 0(init), (0.0870) on test, (0.0021, 0.0054, 0.0025) on target. [3.3s]
Iteration 1, loss = 72.84069 [3.8s], (0.0817) on test, (0.0043, 0.0054, 0.0028) on target. [2.0s]
```

```
Iteration 196, loss = 21.68057 [8.3s], (0.5801) on test, (0.0000, 0.0000, 0.0000) on target. [4.4s]
Iteration 197, loss = 21.62651 [8.1s], (0.5769) on test, (0.0000, 0.0000, 0.0000) on target. [4.6s]
Iteration 198, loss = 21.61202 [7.9s], (0.5811) on test, (0.0000, 0.0011, 0.0003) on target. [3.2s]
Iteration 199, loss = 21.56540 [6.0s], (0.5822) on test, (0.0000, 0.0011, 0.0003) on target. [3.0s]
Iteration 200, loss = 21.53406 [6.3s], (0.5864) on test, (0.0000, 0.0000, 0.0000) on target. [3.0s]
```

# 4.个人方法改进

## 新方法基本思想:

首先假设攻击者知道每个item的popularity,那么它可以在攻击之前首先构造一个模型,使得target item的embedding为最受欢迎的几个item embedding的平均.为了更好地promote,可以将这个embedding加倍.

然而实际场景下攻击者不知道最受欢迎的item,这可以通过item embedding的l2 norm估计:一般来说,norm越大的item对应的item越受欢迎.

核心代码讲解:

```
import torch
import numpy as np
from parse import args
import torch.nn as nn
import math

class OurAttackClient(nn.Module):
    def __init__(self, target_items):
        super().__init__()
        ...

    def eval_(self, _items_emb):
        # 评估函数，返回 None, None（可以进一步根据需要实现特定的评估功能）

    def compute_k_popularities(self, k, items_emb):
        # 计算基于物品嵌入向量范数的前 k 个最受欢迎的物品
        norms = torch.norm(items_emb, dim=1)
        self.k_popularities = torch.argsort(norms, descending=True)[:k]

    def train_(self, items_emb):
        # 训练攻击模型的函数
        with torch.no_grad():
            if self.global_rounds == args.attack_round:
                # 如果处于攻击轮次，计算 k_popularities 以生成 target_model
                self.compute_k_popularities(args.k, items_emb)
                top_k_embedding = items_emb[self.k_popularities]
                average_top_k_embedding = torch.mean(top_k_embedding, axis=0)
                self.target_model = items_emb.clone()
                # 更新 target_model，将目标物品的嵌入向量更新为
average_top_k_embedding * 10
                self.target_model[self.target_items] = average_top_k_embedding *
10

            if self.global_rounds < args.attack_round:
                # 如果不是攻击轮次，返回 None, None, None（可以根据具体条件进一步实现特定
的逻辑）
                self.global_rounds += 1
                return None, None, None

            self.global_rounds += 1
            # 计算 items_emb_model_update，通过从 target_model 中减去 items_emb，然
后乘以 alpha 进行缩放
            items_emb_model_update = (self.target_model - items_emb) *
args.alpha
            # 选择要进行模型更新的物品（选择差异范数最大的 args.items_limit -
len(self.target_items) 个物品）
            chosen_items = torch.argsort(torch.norm(items_emb_model_update,
dim=1), descending=True)[:args.items_limit - len(self.target_items)]
```

```
            # 从 chosen_items 中排除目标物品，以避免冗余更新
            chosen_items = torch.tensor(list(set(chosen_items.tolist()) -
set(self.target_items))).to(args.device)
            # 将目标物品添加到 chosen_items 以进行更新
            chosen_items = torch.cat((chosen_items,
torch.tensor(self.target_items).to(args.device)), dim=0)
        return chosen_items, items_emb_model_update[chosen_items], None
```

结果展示:

和论文中的方法进行效果比较,采用的参数是clients_limit=0.03,part_percent=0.1,最终效果如下,新方法优于论文方法.上面是论文方法的结果下面是新方法

```
Iteration 276, loss = 13.58421 [3.2s], (0.6045) on test, (0.0804, 0.1318, 0.0694) on target. [1.0s]
Iteration 277, loss = 13.58352 [3.1s], (0.5917) on test, (0.0825, 0.1318, 0.0699) on target. [1.0s]
Iteration 278, loss = 13.58283 [2.9s], (0.5822) on test, (0.0815, 0.1329, 0.0706) on target. [0.9s]
Iteration 279, loss = 13.57993 [3.1s], (0.5737) on test, (0.0815, 0.1308, 0.0694) on target. [1.0s]
Iteration 280, loss = 13.57855 [3.4s], (0.5854) on test, (0.0793, 0.1297, 0.0684) on target. [1.0s]
Iteration 281, loss = 13.57725 [3.2s], (0.5832) on test, (0.0772, 0.1275, 0.0668) on target. [1.0s]
Iteration 282, loss = 13.57383 [3.2s], (0.5928) on test, (0.0804, 0.1286, 0.0687) on target. [1.0s]
Iteration 283, loss = 13.57536 [3.1s], (0.5960) on test, (0.0793, 0.1275, 0.0676) on target. [0.9s]
Iteration 284, loss = 13.57221 [3.2s], (0.5875) on test, (0.0793, 0.1286, 0.0687) on target. [0.9s]
Iteration 285, loss = 13.57268 [3.1s], (0.5970) on test, (0.0804, 0.1297, 0.0692) on target. [0.9s]
Iteration 286, loss = 13.56916 [2.8s], (0.5875) on test, (0.0782, 0.1297, 0.0689) on target. [0.9s]
Iteration 287, loss = 13.57073 [2.8s], (0.5907) on test, (0.0782, 0.1318, 0.0697) on target. [0.9s]
Iteration 288, loss = 13.56915 [2.7s], (0.5907) on test, (0.0804, 0.1361, 0.0723) on target. [0.9s]
Iteration 289, loss = 13.56913 [3.1s], (0.5928) on test, (0.0836, 0.1383, 0.0734) on target. [0.9s]
Iteration 290, loss = 13.56523 [3.4s], (0.5949) on test, (0.0836, 0.1393, 0.0736) on target. [1.0s]
Iteration 291, loss = 13.56404 [3.3s], (0.5970) on test, (0.0879, 0.1468, 0.0777) on target. [1.0s]
Iteration 292, loss = 13.56219 [3.2s], (0.5928) on test, (0.0868, 0.1426, 0.0752) on target. [1.0s]
Iteration 293, loss = 13.56148 [3.3s], (0.5875) on test, (0.0857, 0.1426, 0.0752) on target. [0.9s]
Iteration 294, loss = 13.56031 [3.2s], (0.5896) on test, (0.0879, 0.1447, 0.0770) on target. [1.0s]
Iteration 295, loss = 13.55905 [3.2s], (0.5907) on test, (0.0900, 0.1490, 0.0783) on target. [1.0s]
Iteration 296, loss = 13.55483 [3.2s], (0.6034) on test, (0.0911, 0.1597, 0.0833) on target. [0.9s]
Iteration 297, loss = 13.55668 [2.7s], (0.5885) on test, (0.0932, 0.1651, 0.0853) on target. [0.9s]
Iteration 298, loss = 13.55769 [3.0s], (0.5864) on test, (0.0922, 0.1640, 0.0858) on target. [0.9s]
Iteration 299, loss = 13.55188 [3.0s], (0.5970) on test, (0.0932, 0.1672, 0.0862) on target. [0.9s]
Iteration 300, loss = 13.55419 [2.7s], (0.5864) on test, (0.0922, 0.1693, 0.0868) on target. [0.9s]
```

```
Iteration 276, loss = 14.61185 [3.0s], (0.5938) on test, (0.9753, 0.9796, 0.9739) on target. [1.0s]
Iteration 277, loss = 14.63897 [3.0s], (0.5716) on test, (0.9753, 0.9775, 0.9704) on target. [1.0s]
Iteration 278, loss = 14.60908 [2.9s], (0.5854) on test, (0.9753, 0.9786, 0.9721) on target. [1.0s]
Iteration 279, loss = 14.61881 [3.0s], (0.5928) on test, (0.9753, 0.9786, 0.9722) on target. [0.9s]
Iteration 280, loss = 14.63068 [3.0s], (0.5843) on test, (0.9764, 0.9786, 0.9713) on target. [0.9s]
Iteration 281, loss = 14.62653 [2.9s], (0.5832) on test, (0.9732, 0.9786, 0.9707) on target. [0.9s]
Iteration 282, loss = 14.64172 [3.0s], (0.5981) on test, (0.9743, 0.9775, 0.9703) on target. [0.9s]
Iteration 283, loss = 14.61922 [3.2s], (0.5938) on test, (0.9721, 0.9775, 0.9696) on target. [0.9s]
Iteration 284, loss = 14.60825 [3.0s], (0.5864) on test, (0.9732, 0.9775, 0.9701) on target. [0.9s]
Iteration 285, loss = 14.61918 [2.9s], (0.5769) on test, (0.9743, 0.9753, 0.9683) on target. [1.0s]
Iteration 286, loss = 14.61683 [3.0s], (0.5864) on test, (0.9743, 0.9775, 0.9715) on target. [0.9s]
Iteration 287, loss = 14.61739 [2.9s], (0.5779) on test, (0.9732, 0.9775, 0.9700) on target. [0.9s]
Iteration 288, loss = 14.60065 [3.1s], (0.5949) on test, (0.9732, 0.9775, 0.9693) on target. [0.9s]
Iteration 289, loss = 14.60834 [3.3s], (0.5907) on test, (0.9743, 0.9775, 0.9700) on target. [0.9s]
Iteration 290, loss = 14.59413 [2.8s], (0.5843) on test, (0.9732, 0.9764, 0.9684) on target. [0.9s]
Iteration 291, loss = 14.59046 [3.0s], (0.5875) on test, (0.9764, 0.9775, 0.9718) on target. [1.0s]
Iteration 292, loss = 14.60469 [3.1s], (0.5896) on test, (0.9753, 0.9786, 0.9703) on target. [1.0s]
Iteration 293, loss = 14.59402 [3.2s], (0.5790) on test, (0.9732, 0.9775, 0.9702) on target. [1.0s]
Iteration 294, loss = 14.59323 [3.1s], (0.5864) on test, (0.9732, 0.9764, 0.9684) on target. [1.0s]
Iteration 295, loss = 14.57084 [3.0s], (0.5864) on test, (0.9732, 0.9775, 0.9698) on target. [0.9s]
Iteration 296, loss = 14.59494 [2.9s], (0.5854) on test, (0.9743, 0.9775, 0.9695) on target. [0.9s]
Iteration 297, loss = 14.57455 [3.0s], (0.5854) on test, (0.9732, 0.9764, 0.9689) on target. [0.9s]
Iteration 298, loss = 14.57047 [2.8s], (0.6002) on test, (0.9732, 0.9775, 0.9701) on target. [0.9s]
Iteration 299, loss = 14.58484 [2.7s], (0.5875) on test, (0.9743, 0.9764, 0.9704) on target. [0.9s]
Iteration 300, loss = 14.58700 [2.8s], (0.5864) on test, (0.9732, 0.9786, 0.9703) on target. [0.9s]
```

同时设置前50轮只收集信息,第51轮开始攻击,可以看到结果中的数据在第51轮从零突变到0.98+,并维持在较高水平.(上面是论文方法的结果下面是新方法)

```
Arguments: attack='FedRecAttack,dim=32,path='Data/',k=50,lambda=1,alpha=1,attack_round=50,dataset=ml-100k/,device=cuda,lr=0.05,epochs=300,batch_size=
256,grad_limit=1.0,clients_limit=0.03,items_limit=60,part_percent=1,attack_lr=0.05,attack_batch_size=256,aggregation=mean,gpu=1
Load data done [6.4 s]. #user=971, #item=1682, #train=99856, #test=943
Target items: [894].
output format: ({Sampled HR@10}), ({ER@5},{ER@10},{NDCG@10})
Iteration 0(init), (0.0848) on test, (0.0021, 0.0054, 0.0075) on target. [0.9s]
Iteration 1, loss = 72.84150 [2.6s], (0.1038) on test, (0.0835, 0.1115, 0.0722) on target. [0.9s]
Iteration 2, loss = 72.83262 [2.6s], (0.1183) on test, (0.3451, 0.3848, 0.3219) on target. [0.9s]
Iteration 3, loss = 72.82125 [2.6s], (0.1326) on test, (0.6034, 0.6313, 0.5834) on target. [0.9s]
Iteration 4, loss = 72.80532 [2.5s], (0.1453) on test, (0.7618, 0.7706, 0.7183) on target. [0.9s]
Iteration 5, loss = 72.77523 [2.8s], (0.1972) on test, (0.8789, 0.8896, 0.8703) on target. [0.9s]
Iteration 6, loss = 72.78622 [3.3s], (0.2503) on test, (0.9411, 0.9443, 0.9374) on target. [1.0s]
Iteration 7, loss = 72.52948 [3.0s], (0.2768) on test, (0.9668, 0.9668, 0.9658) on target. [1.0s]
Iteration 8, loss = 72.05746 [3.1s], (0.3001) on test, (0.9754, 0.9775, 0.9764) on target. [0.9s]
Iteration 9, loss = 70.82756 [3.2s], (0.3043) on test, (0.9861, 0.9861, 0.9861) on target. [1.0s]
Iteration 10, loss = 67.86239 [3.1s], (0.2884) on test, (0.9925, 0.9925, 0.9925) on target. [0.9s]
Iteration 11, loss = 61.99706 [3.2s], (0.2812) on test, (0.9925, 0.9925, 0.9925) on target. [0.9s]
Iteration 12, loss = 54.34340 [3.2s], (0.2948) on test, (0.0450, 0.0536, 0.0409) on target. [0.9s]
Iteration 13, loss = 47.88914 [3.2s], (0.3139) on test, (0.0054, 0.0064, 0.0064) on target. [0.9s]
Iteration 14, loss = 43.76459 [2.6s], (0.3484) on test, (0.0032, 0.0032, 0.0026) on target. [0.9s]
Iteration 15, loss = 41.19883 [3.1s], (0.3423) on test, (0.0021, 0.0021, 0.0021) on target. [0.9s]
Iteration 16, loss = 39.55557 [3.1s], (0.3584) on test, (0.0021, 0.0021, 0.0021) on target. [0.9s]
Iteration 17, loss = 38.39977 [3.1s], (0.3686) on test, (0.0043, 0.0043, 0.0043) on target. [0.9s]
Iteration 18, loss = 37.54890 [3.0s], (0.3775) on test, (0.0032, 0.0032, 0.0032) on target. [0.9s]
Iteration 19, loss = 36.85732 [3.1s], (0.3765) on test, (0.0032, 0.0032, 0.0032) on target. [0.9s]
```

```
Iteration 41, loss = 24.80048 [2.6s], (0.5376) on test, (0.0000, 0.0000, 0.0000) on target. [0.9s]
Iteration 42, loss = 24.46308 [2.3s], (0.5217) on test, (0.0000, 0.0000, 0.0000) on target. [0.9s]
Iteration 43, loss = 24.13988 [2.5s], (0.5387) on test, (0.0000, 0.0000, 0.0000) on target. [0.9s]
Iteration 44, loss = 23.79102 [2.9s], (0.5334) on test, (0.0000, 0.0000, 0.0000) on target. [0.9s]
Iteration 45, loss = 23.48067 [3.0s], (0.5355) on test, (0.0000, 0.0000, 0.0000) on target. [0.9s]
Iteration 46, loss = 23.18168 [3.0s], (0.5376) on test, (0.0000, 0.0000, 0.0000) on target. [0.9s]
Iteration 47, loss = 22.88689 [2.9s], (0.5483) on test, (0.0000, 0.0000, 0.0000) on target. [0.9s]
Iteration 48, loss = 22.60305 [2.9s], (0.5323) on test, (0.0000, 0.0000, 0.0000) on target. [0.9s]
Iteration 49, loss = 22.31694 [2.9s], (0.5493) on test, (0.0000, 0.0000, 0.0000) on target. [0.9s]
Iteration 50, loss = 22.05977 [2.9s], (0.5546) on test, (0.0000, 0.0000, 0.0000) on target. [0.9s]
Iteration 51, loss = 22.00500 [2.8s], (0.5525) on test, (0.9882, 0.9882, 0.9861) on target. [0.9s]
Iteration 52, loss = 22.11385 [2.3s], (0.5567) on test, (0.9893, 0.9893, 0.9889) on target. [0.9s]
Iteration 53, loss = 21.99215 [2.6s], (0.5525) on test, (0.9893, 0.9893, 0.9893) on target. [0.9s]
Iteration 54, loss = 21.75483 [2.7s], (0.5620) on test, (0.9893, 0.9893, 0.9893) on target. [0.9s]
Iteration 55, loss = 21.54424 [2.9s], (0.5578) on test, (0.9893, 0.9893, 0.9889) on target. [0.9s]
Iteration 56, loss = 21.33480 [3.0s], (0.5620) on test, (0.9893, 0.9904, 0.9896) on target. [0.9s]
Iteration 57, loss = 21.10641 [3.0s], (0.5599) on test, (0.9893, 0.9904, 0.9896) on target. [0.9s]
Iteration 58, loss = 20.90411 [3.0s], (0.5790) on test, (0.9893, 0.9893, 0.9893) on target. [1.0s]
Iteration 59, loss = 20.71460 [3.0s], (0.5620) on test, (0.9893, 0.9893, 0.9889) on target. [1.0s]
Iteration 60, loss = 20.53967 [3.0s], (0.5673) on test, (0.9893, 0.9893, 0.9889) on target. [1.0s]
Iteration 61, loss = 20.35701 [3.1s], (0.5684) on test, (0.9893, 0.9893, 0.9885) on target. [0.9s]
Iteration 62, loss = 20.18388 [3.1s], (0.5673) on test, (0.9893, 0.9893, 0.9885) on target. [0.9s]
Iteration 63, loss = 20.02223 [3.1s], (0.5663) on test, (0.9893, 0.9893, 0.9889) on target. [1.0s]
Iteration 64, loss = 19.88250 [3.4s], (0.5642) on test, (0.9893, 0.9893, 0.9889) on target. [0.9s]
Iteration 65, loss = 19.74218 [2.8s], (0.5726) on test, (0.9893, 0.9893, 0.9885) on target. [0.9s]
Iteration 66, loss = 19.57523 [2.6s], (0.5642) on test, (0.9893, 0.9893, 0.9885) on target. [0.9s]
```