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Introduction

Recommender systems are widely used in e-commerce and greatly change people's online shopping behaviors. However, there is still room to improve recommendation performance. We are working on three different directions to improve it.

- Users' purchase behaviors have several stages, and we use multi-task learning to model these stages.
- Various behaviors generate various implicit feedbacks.
- Search behavior can be better exploited for improving recommendation.

Dataset

We utilize a huge dataset including diverse user behaviors collected from a widely used e-commerce website in China. The dataset contains about 8 million users and 2 million items in a time span of one month, which provides a rare opportunity to extensively study the user behavior and how to use it to improve recommendation. It consists of 5 parts:

- Action log
  - ➤ View, search, click, collect, add to cart, and buy
- Recommendation log
- Trade order log
- User information
- Item information

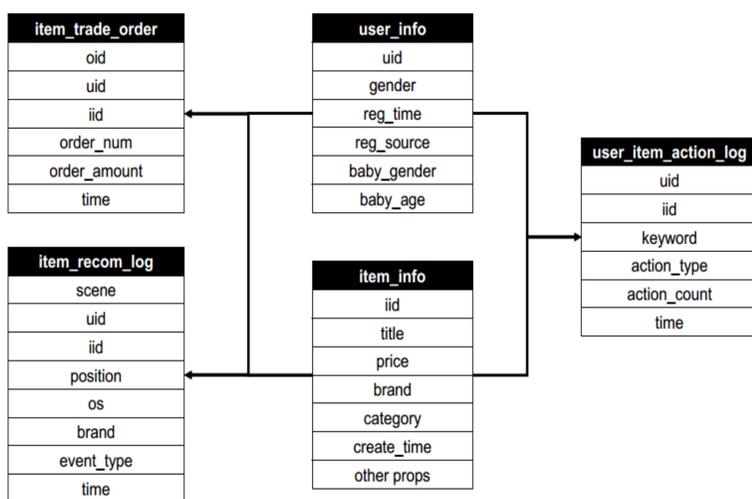The details of dataset is show in Figure 1.

Figure 1 Details of dataset

Methodologies
Multi-task-learning neural network

In our work, with various kinds of behaviors, multi-task learning is an intuitive solution, which is a widely used method to solve several tasks simultaneously. We build a cascaded neural network to characterize three behaviors in our dataset: click, add to chart, and buy. The detail of the cascaded network is show as Figure 2.
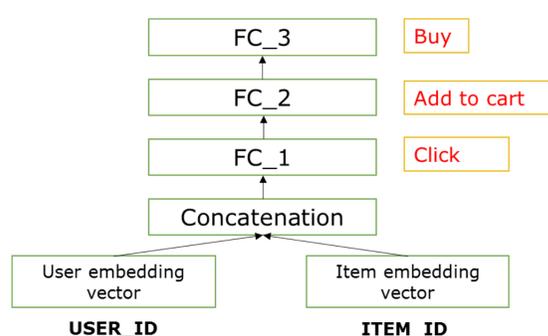

Figure 2 Framework of multi-task-learning neural network

Framework:
- Embedding of user and item
- Three FC networks to predict three behaviors

Training:
- Feed whole network with three kinds of disrupted samples
- Feed three networks separately

Multi-implicit feedback

Implicit feedback has been proved to be a significant factor in a real recommender system when explicit feedback is lacked. It is obvious that multiple behaviors generate multi-implicit feedbacks.

Implicit feedbacks generated by multiple behaviors:
- View without click
- Click without buy

Methods:
- Improved BPR
- Improved eALS

Exploiting search behaviors

In our work, we believe search behaviors should be more focused, understood and exploited. It is intuitive to conduct a co-matrix factorization as there are two kinds of behaviors: search and buy.

Co-matrix factorization shown in Figure3:
- User-Item purchase matrix
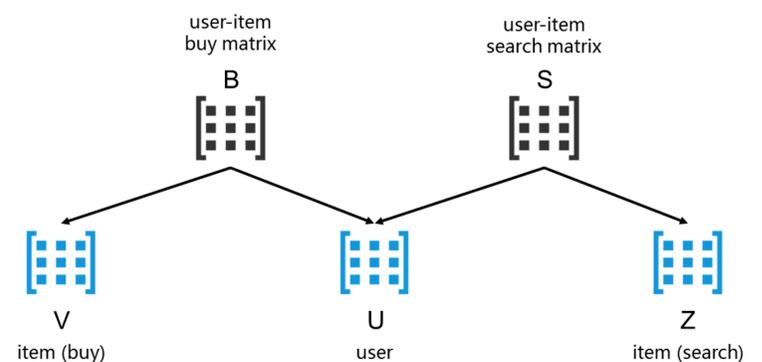- User-Item search matrix
- A common user component

Figure 3 Framework of co-matrix factorization

Another method is to consider the sequence of two behaviors. Sequence to sequence learning is a well studied problem in NMT(Neural machine translation). In our work, we apply it to model two ubiquitous behavior sequences: search and buy.

- From search word sequence to bought item sequence
- Use attention to obtain the weight of different words

Summary and conclusions

Based on a real dataset containing many kinds of user behaviors, we proposed three different aspects to improve recommendation: cascaded neural network, multi-implicit feedback and a better exploiting of search behaviors. The experiments prove that in real recommender system, the proper use of multiple behaviors will bring considerable gain.