Hybrid Session-based News Recommendation using Recurrent Neural Networks

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Abstract

We describe a hybrid meta-architecture – the CHAMELEON – for session-based news recommendation that is able to leverage a variety of information types using Recurrent Neural Networks. We evaluated our approach on two public datasets, using a temporal evaluation protocol that simulates the dynamics of a news portal in a realistic way. Our results confirm the benefits of modeling the sequence of session clicks with RNNs and leveraging side information about users and articles, resulting in significantly higher recommendation accuracy and catalog coverage than other session-based algorithms.

1. Introduction

Recommender systems help users to deal with information overload by providing tailored item suggestions to them. One of the earliest application domains is the recommendation of online news (Karimi et al., 2018). News recommendation is sometimes considered as being particularly difficult, as it has a number of distinctive characteristics (Zheng et al., 2018). Among other challenges, news recommenders have to deal with a constant stream of news articles being published, which at the same time can become outdated very quickly. Another challenge is that the system often cannot rely on long-term user preference profiles. Typically, most users are not logged in and their short-term reading interests must be estimated from only a few logged interactions, leading to a session-based recommendation problem (Quadrana et al., 2018).

In recent years, we observed an increased interest in the problem of session-based recommendation, where the task is to recommend relevant items given an ongoing user session. Recurrent Neural Networks (RNN) represent a natural choice for sequence prediction tasks, as they can learn models from sequential data. GRU4Rec (Hidasi et al., 2016) was one of the first neural session-based recommendation techniques, and a number of other approaches were proposed in recent years that rely on deep learning architectures, as in (Liu et al., 2018; Li et al., 2017).

However, as shown in (Jannach & Ludewig, 2017; Ludewig & Jannach, 2018; Ludewig et al., 2019), neural approaches that only rely on logged item interactions have certain limitations and they can, depending on the experimental setting, be outperformed by simpler approaches based, e.g., nearest-neighbor techniques. Differently from previous works, we therefore leverage multiple types of side information with RNNs, including textual article embeddings, as well as the context of users and articles. Furthermore, we propose a meta-architecture to address the aforementioned challenges of recommending in the news domain.

2. Technical Contribution

Our approach is based upon CHAMELEON (Moreira, 2018; Moreira et al., 2018; 2019b;a), which is a Deep Learning Meta-Architecture for News Recommendation. It supports session-based news recommendation scenarios, modeling the sequence of user clicks using Recurrent Neural Networks. The resulting system is a hybrid recommender system, which addresses the permanent user and item cold-start problem in the news domain by leveraging the textual content of news articles, the article context (e.g., recent popularity and recency) and the user context (e.g., time, location, device, previous session clicks).

Figure 1 shows our instantiation of the CHAMELEON framework with its two main modules: the ACR module on the left creates distributed representations of articles’ textual content. The NAR module on the right is responsible to generate next-click predictions. The NAR module is trained on a ranking loss function based on similarities, which is designed to recommend fresh articles without retraining. As proposed for the DSSM loss function (Huang et al., 2013), it is trained to maximize the likelihood of correctly predicting the next clicked article given a user session.
3. Evaluation Protocol

The evaluation was performed as follows: (1) Recom- menders are continuously trained on users’ sessions ordered by time and grouped by hours. Each five hours, the recom- menders are evaluated on sessions from the next hour; (2) For each session in the evaluation set, we incrementally re- vealed one click after the other to the recommender; and (3) For each click to be predicted, we created a set containing 50 negative samples articles (not clicked by the user in her session) and compute top-N metrics about accuracy, item coverage, and novelty.

Experiments were performed with two public real-world datasets from the G1 (Moreira et al., 2018) and Adressa (Gulla et al., 2017) news portals, described in Table 1.

We evaluated the following recommendation quality factors for the top-N ranked items: accuracy – Hit Rate (HR@n) and Mean Reciprocal Rank (MRR@n); item coverage – (COV) (i.e., the number of distinct articles that appeared in any top- N list divided by the number of recommendable articles); and novelty – ESI-R, which is based on item popularity, returning higher values when recommending long-tail items.

As baseline algorithms for session-based recommendation, we have used: two neural approaches (GRU4Rec (Hidasi et al., 2016) and SR-GNN (Wu et al., 2019)); association rules-based methods (Co-Occurrence (CO) and Sequential Rules (SR) (Ludewig & Jannach, 2018)); neighborhood-based methods (Item-kNN (Hidasi et al., 2016) and Vector

5. Conclusion

CHAMELEON was specifically designed to address news recommendation challenges such as (a) the short lifetime of the recommendable items and (b) the lack of longer-term preference profiles of the users. In the extensive experiments performed, CHAMELEON was able to provide recommendations with much higher accuracy than all other evaluated algorithms, and it led to the second best item coverage.

Table 1. Statistics of the datasets used for the experiments.

| Language | Globo.com (G1) | Adressa |
|----------|----------------|---------|
| Period (days) | 16 | 16 |
| # users | 322,897 | 314,661 |
| # sessions | 1,048,594 | 982,210 |
| # clicks | 2,988,181 | 2,648,999 |
| # articles | 46,033 | 13,820 |
| Avg. Sessions length (clicks) | 2.84 | 2.70 |

Table 2. Evaluation of recommendation quality factors

| Recommender | HR@10  | MRR@10 | COV@10 | ESI-R@10 |
|-------------|--------|--------|--------|----------|
| GI dataset  |        |        |        |          |
| CHAMELEON   | **0.6738** | **0.3458** | 0.6373 | 6.4177 |
| SR          | 0.5900  | 0.2889 | 0.2763 | 5.9747 |
| Item-kNN    | 0.5707  | 0.2801 | 0.3913 | 6.5909 |
| CO          | 0.5689  | 0.2626 | 0.2499 | 5.5728 |
| V-SkNN      | 0.5467  | 0.2494 | 0.1355 | 5.1760 |
| SR-GNN      | 0.5144  | 0.2467 | 0.3196 | 5.4280 |
| GRU4Rec     | 0.4669  | 0.2092 | 0.6333 | 5.2332 |
| RP          | 0.4577  | 0.1993 | 0.0218 | 4.4904 |
| CB          | 0.3643  | 0.1676 | **0.6774** | 8.1531* |

| Adressa dataset |        |        |        |          |
| CHAMELEON | **0.7018** | **0.3421** | 0.7926 | 5.3410 |
| SR          | 0.6288  | 0.3022 | 0.4604 | 5.4443 |
| Item-kNN    | 0.6179  | 0.2819 | 0.5314 | 5.4675 |
| CO          | 0.6131  | 0.2768 | 0.4220 | 5.0789 |
| V-SkNN      | 0.6140  | 0.2723 | 0.1997 | 4.6018 |
| SR-GNN      | 0.6122  | 0.2991 | 0.5197 | 5.1013 |
| GRU4Rec     | 0.4958  | 0.2200 | 0.5143 | 5.0571 |
| RP          | 0.5648  | 0.2481 | 0.0542 | 4.1465 |
| CB          | 0.3307  | 0.1253 | **0.8875** | 7.6715* |

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As errors around the reported averages were normally distributed, we used paired Student’s t-tests with Bonferroni correction at \( p < 0.001 \) for significance tests.
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