Jw111 - Junyang Wang

Learning to Rank Introduction – technology review

Introduction

In the emergence of waves of new information each day, Information retrieval is becoming more and more crucial in helping people get the information they want accurately and efficiently, from piles of unorganized documents. In the heart of every information retrieval system, a ranker is used to intake a user query, match it against its collection of documents and output relevance judgments. Many conventional ranking algorithms are based on heuristics such as term frequency and inverse document frequency. As an increasing amount of user behavior data are becoming available, machine learning technologies are being adopted to generate the state of art ranking models.

Learning-to-rank refers to the methods where machine learning is applied to learn the best combinations of predefined features for ranking. For example, machine learning could be applied to learn the optimal parameters in BM25 for k1, b and k3. Different ranking algorithms could also be combined to make a decision, the weights for the combination could also be learned using machine learning. In this technology review, we will introduce three major approaches to learning to Rank.

Learning to Rank approaches

The three major approaches to Learning to Rank are known as pointwise, pairwise, and listwise.

1. **Pointwise ranking**

   Pointwise approach take a document as input to predict a score. A classifier (putting similar documents in the same class) or regressor (giving similar documents a similar function value, so that we can assign them similar preferences during the ranking procedure) is trained to minimize the cost function and predict how relevant each document is for the current query. The final ranking is calculated by sorting the documents by their relevance in the descending order. Pointwise approaches optimize for predicting a query for each documents. For example, ranking a product recommendations based on the probability a user clicks on an item.

   Since pointwise approach only take one input at a time, the relative order between documents cannot be considered in the learning process. Moreover, the query-level and position-based properties cannot be well considered by pointwise approach.

2. **Pairwise ranking**

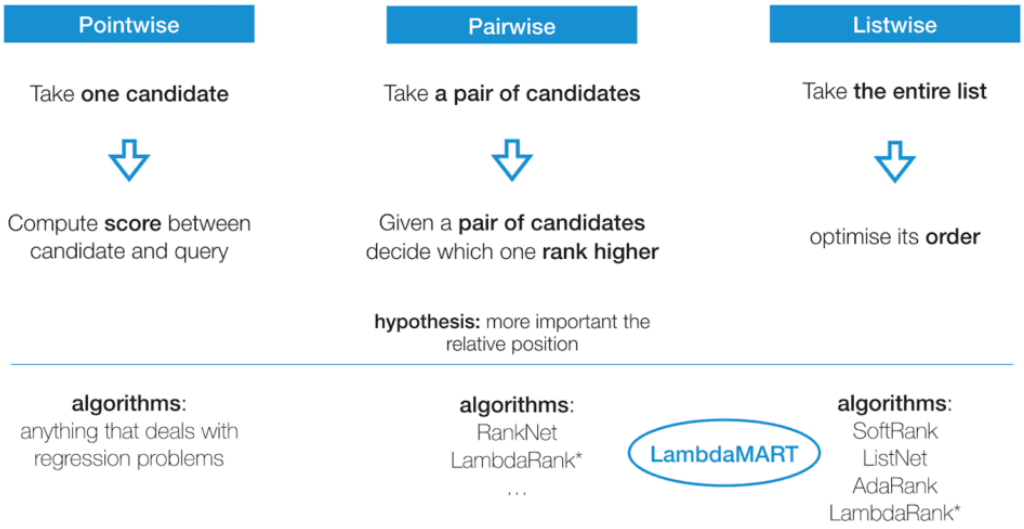
   Pairwise approach take a pair of documents as input and predict a relative order of the input pairs. Pairwise approaches try to learn the relationship between a pair of documents with its relevance under the same query. A cost function is used to maximize the correctness of pairwise preference and minimize the number of cases where the pair of results are in the wrong order relative to the ground truth.

   In general, the pairwise approaches are better than the pointwise approaches, since it can model the relative order between each documents. However, when dealing with a documents that are distributed in an imbalanced manner, the input pair number can be

quadratic (worse case) to the total document number.

3. Listwise ranking

Listwise approach take an entire list as input and produce the order of the document in the list for a query. So instead of looking at single document or pairs, the entire document list is evaluated. The listwise approach can be divided into two sub-categories, direct optimization of IR measures and minimization of Ranking Losses. For the first sub-categories, the goal is directly optimizing what is used to evaluate the ranking performance, such as NDCG, MAP and AUC. In the second sub-categories, the loss function measures the inconsistency between the output list order and ground truth list order. We can improve output ordering result by minimize the loss function.



Conclusion

Learning to rank for Information Retrieval is a task to automatically construct a ranking model using training data, such that the model can sort web page according to their degrees of relevance, preference, or importance. Many IR problems are by nature ranking problems, and many IR technologies can be potentially enhanced by using learning-to-rank techniques. In this technology review, pointwise approaches, pairwise approaches and listwise approaches are introduced to handle the ranking problem. Typically, the pairwise approaches are better than pointwise approaches, however, the pairwise approaches do not always optimize the entire ranking. Compared to the pairwise approaches, the listwise approaches can handle the ranking problem in a more straightforward way, however some mathematical techniques such as modifying the non-continuous function to continuous function to optimize the loss function is needed.

Reference

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