Multi-Task Learning for Document Ranking and Query Suggestion

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Objectives

Understanding users' information need is essential for a search engine to provide relevant search results. As a user's click behavior and query reformulation are driven by the shared underlying search intent, we argue that jointly modeling both tasks can benefit each other. We model search context within a session via a recurrent latent state in a deep neural network to guide the following:

- The generation of clicks for the current query
- The formation of the next query

Motivation

To understand the user's intent accurately, user's previously submitted queries can be utilized.

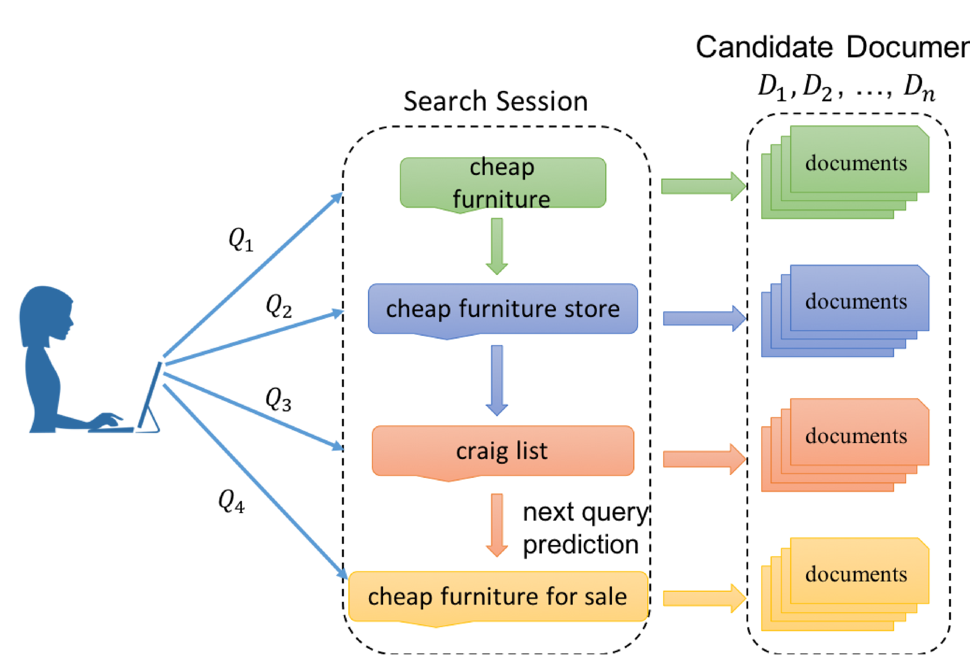

Figure 1: A user with intent of buying "cheap furnitures" is searching for relevant documents in web.

- For the query, "craig list", we can better server the user by promoting documents related to furnitures.
- The user's next query, "cheap furniture for sale" can be better inferred if previous in-session queries are taken into account.

Major Components

- Document Ranker: ranks a list of candidate documents given current query and previous queries.

$$P(D_j|Q_i, S_{i-1}) = \sigma\left(D_j^T \tanh(W_r[Q_i, S_{i-1}] + b_r)\right)$$

- Query Recommender: generates next query in a sequence-to-sequence fashion following [1].

$$P(Q_i|Q_{1:i-1}) = \prod_{t=1}^{q} P(w_i^t|w_i^{1:t-1}, Q_{1:i-1})$$

Our Contribution

Multi-task learning of document ranking and query suggestion benefits each other. Our proposed framework is generalizable and shows improvement when adapted to other exsiting neural IR models.

Multi-Task Neural Session Relevance Framework

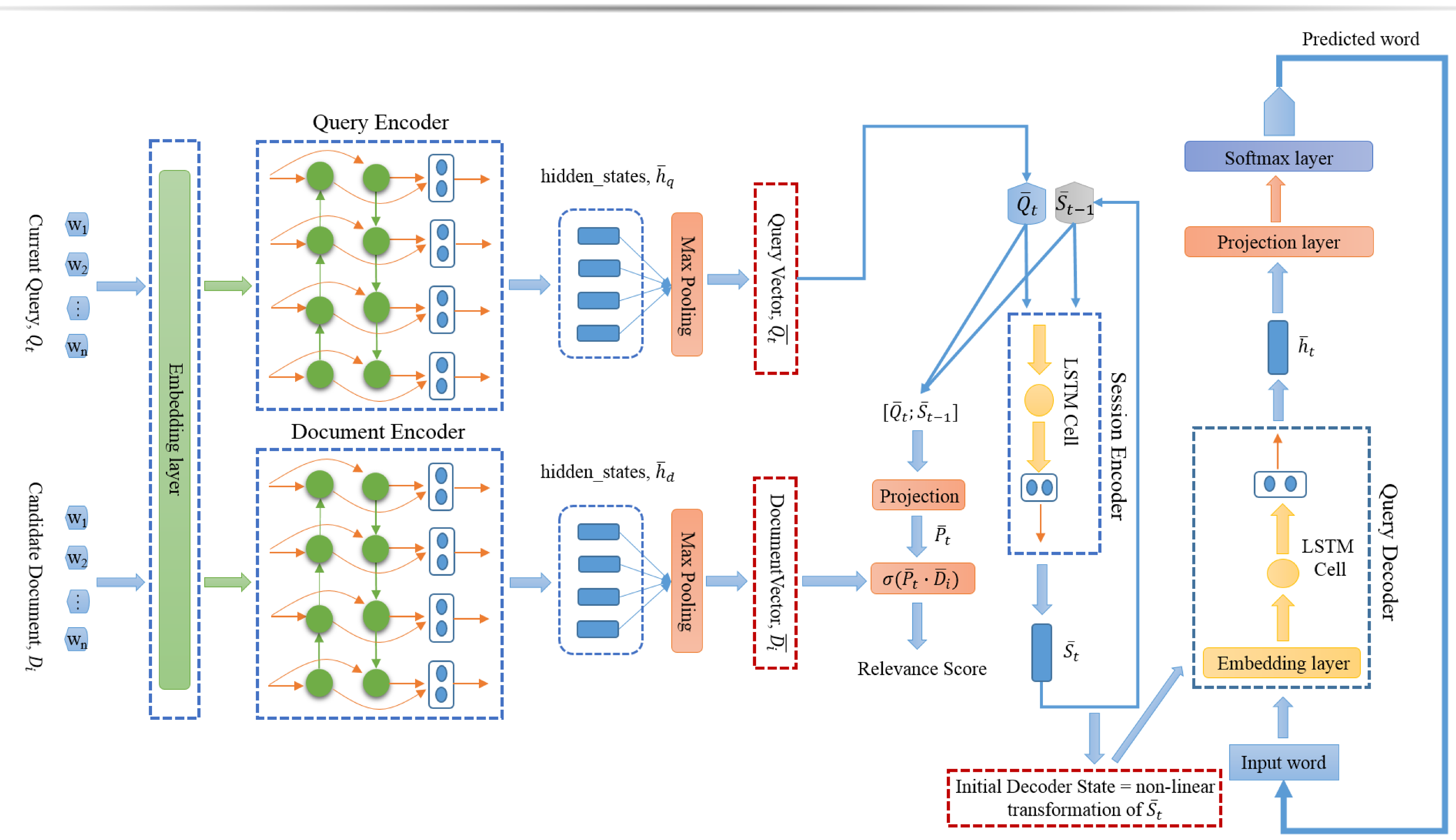

Figure 2: Architecture of the Multi-task Neural Session Relevance Framework (M-NSRF). M-NSRF uses bi-LSTM with max pooling to form query and document representations and use LSTM to gather session-level information. These recurrent states (current query representation and session-level recurrent state, which summarizes all previous queries) are used by query decoder and document ranker for predicting next query and computing relevance scores.

Multi-Task Learning Objective

Our model is trained end-to-end by minimizing the following loss function with regularization.

$$\mathcal{L} \equiv -\frac{1}{m} \underbrace{\sum_j^m o_j \times \log\ P(D_j|Q_i) + (1 - o_j) \times \log(1 - P(D_j|Q_i))}_{\text{Binary cross entropy}} - \underbrace{\sum_t^q \log P(w_i^t|w_i^{1:i-1}, Q_{1:i-1})}_{\text{Negative log-likelihood}}$$

Document Ranking Quality

Model Name	MAP	MRR	NDCG @1	NDCG @5	NDCG @10
CDSSM	0.465	0.505	0.369	0.482	0.523
Match-Tensor	0.613	0.621	0.568	0.596	0.618
NSRF	**0.553**	**0.568**	**0.481**	**0.555**	**0.574**
M-NSRF	**0.581**	**0.603**	**0.523**	**0.583**	**0.614**
M-Match-Tensor	0.621	0.634	0.572	0.602	0.632

Table 1: Comparison of different document ranking models.

Query Suggestion Quality

Model Name	BLEU 1	BLEU 2	BLEU 3	BLEU 4	MRR
Seq2seq	24.5	9.7	4.5	1.9	0.229
Seq2seq with attention	28.1	15.7	10.4	8.5	0.252
HRED-qs	**26.4**	**13.6**	**7.9**	**5.8**	**0.231**
M-NSRF	**28.6**	**16.7**	**10.2**	**8.3**	**0.238**

Table 2: Comparison of different query suggestion models.

Qualitative Example

Prev. session queries	types of weapons of mass destruction, weapons of mass destruction, nuclear weapons
Next user query	biological weapons
Suggested next query	destructive nuclear weapons

Table 3: Examples of next query suggested by M-NSRF given all previous queries in a session.

Ablation Study

- Utilizing contextual information benefits both document ranking and query suggestion tasks.
- Attention mechanism improves query suggestion because of high overlapping in real user queries.
- Estimating word embeddings based on search log data results in better performance.

Conclusion

Proposed a context-aware multi-task neural session relevance framework and showed that joint training by sharing session recurrent states across document ranking and query suggestion tasks benefits each other.

References

[1] A. Sordoni, Y. Bengio, H. Vahabi, C. Lioma, J. Grue Simonsen, and J.-Y. Nie. A hierarchical recurrent encoder-decoder for generative context-aware query suggestion. *Proceedings of the 24th ACM CIKM*, pages 553–562, 2015.

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