

instant search. Bridging the gap between the observed incomplete instant search query prefixes and the complete spoken queries (e.g., voice search) to train a unified model is an important and challenging problem.

REFERENCES

- [1] Ziv Bar-Yossef and Naama Kraus. [n.d.]. Context-Sensitive Query Auto-Completion. In *Proceedings of the 20th International Conference on World Wide Web (WWW '11)*. 107–116.
- [2] Ziv Bar-Yossef and Naama Kraus. 2011. Context-Sensitive Query Auto-Completion. In *WWW '11* (Hyderabad, India). Association for Computing Machinery, New York, NY, USA, 107–116. <https://doi.org/10.1145/1963405.1963424>
- [3] Fei Cai and Maarten de Rijke. 2016. Learning from Homologous Queries and Semantically Related Terms for Query Auto Completion. *Inf. Process. Manage.* 52, 4 (July 2016), 628–643. <https://doi.org/10.1016/j.ipm.2015.12.008>
- [4] Fei Cai and Maarten de Rijke. 2016. A Survey of Query Auto Completion in Information Retrieval. *Foundations and Trends® in Information Retrieval* 10, 4 (2016), 273–363. <https://doi.org/10.1561/15000000055>
- [5] Fei Cai, Shangsong Liang, and Maarten de Rijke. 2014. Personalized Document Re-Ranking Based on Bayesian Probabilistic Matrix Factorization. In *SIGIR '14* (Gold Coast, Queensland, Australia). Association for Computing Machinery, New York, NY, USA, 835–838. <https://doi.org/10.1145/2600428.2609453>
- [6] Praveen Chandar, Jean Garcia-Gathright, Christine Hosey, Brian St. Thomas, and Jennifer Thom. 2019. Developing Evaluation Metrics for Instant Search Using Mixed Methods Methods. In *SIGIR '19* (Paris, France). ACM, New York, NY, USA, 925–928. <https://doi.org/10.1145/3331184.3331293>
- [7] Wanyu Chen, Fei Cai, Honghui Chen, and Maarten de Rijke. 2018. Attention-Based Hierarchical Neural Query Suggestion. In *SIGIR '18* (Ann Arbor, MI, USA). ACM, New York, NY, USA, 1093–1096. <https://doi.org/10.1145/3209978.3210079>
- [8] Mostafa Dehghani, Hamed Zamani, Aliaksei Severyn, Jaap Kamps, and W. Bruce Croft. 2017. Neural Ranking Models with Weak Supervision. In *SIGIR '17*. 65–74.
- [9] Jacob Devlin, Ming-Wei Chang, Kenton Lee, and Kristina Toutanova. 2019. BERT: Pre-training of deep bidirectional transformers for language understanding. In *NAACL '19*.
- [10] Giovanni Di Santo, Richard McCreadie, Craig Macdonald, and Iadh Ounis. 2015. Comparing Approaches for Query Autocompletion. In *SIGIR '15* (Santiago, Chile). Association for Computing Machinery, New York, NY, USA, 775–778. <https://doi.org/10.1145/2766462.2767829>
- [11] Nicolas Fiorini and Zhiyong Lu. 2018. Personalized neural language models for real-world query auto completion. In *NAACL '18*. Association for Computational Linguistics, New Orleans - Louisiana, 208–215. <https://doi.org/10.18653/v1/N18-3026>
- [12] Jiafeng Guo, Yixing Fan, Qingyao Ai, and W. Bruce Croft. 2016. A Deep Relevance Matching Model for Ad-Hoc Retrieval. In *CIKM '16* (Indianapolis, Indiana, USA). 55–64.
- [13] Jiafeng Guo, Yixing Fan, Liang Pang, Liu Yang, Qingyao Ai, Hamed Zamani, Chen Wu, W. Bruce Croft, and Xueqi Cheng. 2019. A Deep Look into neural ranking models for information retrieval. *Information Processing & Management* (2019).
- [14] Helia Hashemi, Hamed Zamani, and W. Bruce Croft. 2019. Performance Prediction for Non-Factoid Question Answering. In *ICTIR '19*. 55–58.
- [15] Helia Hashemi, Hamed Zamani, and W. Bruce Croft. 2020. Guided Transformer: Leveraging Multiple External Sources for Representation Learning in Conversational Search. In *SIGIR '20* (Virtual Event, China). Association for Computing Machinery, New York, NY, USA, 1131–1140.
- [16] Xiangnan He, Lizi Liao, Hanwang Zhang, Liqiang Nie, Xia Hu, and Tat-Seng Chua. 2017. Neural Collaborative Filtering. In *WWW '17* (Perth, Australia). International World Wide Web Conferences Steering Committee, Republic and Canton of Geneva, CHE, 173–182. <https://doi.org/10.1145/3038912.3052569>
- [17] Christine Hosey, Lara Vujović, Brian St. Thomas, Jean Garcia-Gathright, and Jennifer Thom. 2019. Just give me what I want: How people use and evaluate music search. In *CHI '19* (Glasgow, UK). Association for Computing Machinery, 1–12.
- [18] Bo-June (Paul) Hsu and Giuseppe Ottaviano. 2013. Space-Efficient Data Structures for Top-k Completion. In *WWW '13* (Rio de Janeiro, Brazil) (*WWW '13*). Association for Computing Machinery, New York, NY, USA, 583–594. <https://doi.org/10.1145/2488388.2488440>
- [19] Po-Sen Huang, Xiaodong He, Jianfeng Gao, Li Deng, Alex Acero, and Larry Heck. 2013. Learning Deep Structured Semantic Models for Web Search Using Clickthrough Data. In *CIKM '13* (San Francisco, California, USA). 2333–2338.
- [20] Aaron Jaech and Mari Ostendorf. 2018. Personalized Language Model for Query Auto-Completion. In *ACL '18*. Association for Computational Linguistics, Melbourne, Australia, 700–705. <https://doi.org/10.18653/v1/P18-2111>
- [21] Kalervo Järvelin and Jaana Kekäläinen. 2002. Cumulated Gain-Based Evaluation of IR Techniques. *ACM Trans. Inf. Syst.* 20, 4 (2002), 422–446.
- [22] Jyun-Yu Jiang, Yen-Yu Ke, Pao-Yu Chien, and Pu-Jen Cheng. 2014. Learning User Reformulation Behavior for Query Auto-Completion. In *SIGIR '14* (Gold Coast, Queensland, Australia). Association for Computing Machinery, New York, NY, USA, 445–454. <https://doi.org/10.1145/2600428.2609614>
- [23] Dimitrios Kastrinakis and Yannis Tzitzikas. 2010. Advancing search query autocompletion services with more and better suggestions. In *ICWE '10*. Springer, 35–49.
- [24] Diederik P. Kingma and Jimmy Ba. 2014. Adam: A Method for Stochastic Optimization. <http://arxiv.org/abs/1412.6980>
- [25] Arlind Kopliku, Karen Pinel-Sauvagnat, and Mohand Bouhanem. 2014. Aggregated search: A new information retrieval paradigm. *ACM Computing Surveys (CSUR)* 46, 3 (2014), 1–31.
- [26] Unni Krishnan, Alistair Moffat, and Justin Zobel. 2017. A Taxonomy of Query Auto Completion Modes. In *ADCS '17* (Brisbane, QLD, Australia). ACM, New York, NY, USA, Article 6, 8 pages. <https://doi.org/10.1145/3166072.3166081>
- [27] Mounia Lalmas. 2011. Aggregated Search. In *Advanced Topics in Information Retrieval*, Massimo Melucci and Ricardo Baeza-Yates (Eds.). The Information Retrieval Series, Vol. 33. Springer, 109–123. https://doi.org/10.1007/978-3-642-20946-8_5
- [28] Liangda Li, Hongbo Deng, Anlei Dong, Yi Chang, Hongyuan Zha, and Ricardo Baeza-Yates. 2015. Analyzing User's Sequential Behavior in Query Auto-Completion via Markov Processes. In *SIGIR '15* (Santiago, Chile). Association for Computing Machinery, New York, NY, USA, 123–132. <https://doi.org/10.1145/2766462.2767723>
- [29] Yanen Li, Anlei Dong, Hongning Wang, Hongbo Deng, Yi Chang, and ChengXiang Zhai. 2014. A Two-Dimensional Click Model for Query Auto-Completion. In *SIGIR '14* (Gold Coast, Queensland, Australia). Association for Computing Machinery, New York, NY, USA, 455–464. <https://doi.org/10.1145/2600428.2609571>
- [30] David Maxwell, Peter Bailey, and David Hawking. 2017. Large-Scale Generative Query Autocompletion (*ADCS 2017*). Association for Computing Machinery, New York, NY, USA, Article 9, 8 pages.
- [31] Bhaskar Mitra. 2015. Exploring Session Context Using Distributed Representations of Queries and Reformulations. In *SIGIR '15* (Santiago, Chile). Association for Computing Machinery, New York, NY, USA, 3–12. <https://doi.org/10.1145/2766462.2767702>
- [32] Bhaskar Mitra and Nick Craswell. 2015. Query Auto-Completion for Rare Prefixes. In *CIKM '15* (Melbourne, Australia). Association for Computing Machinery, New York, NY, USA, 1755–1758. <https://doi.org/10.1145/2806416.2806599>
- [33] Rodrigo Nogueira and Kyunghyun Cho. 2019. Passage Re-ranking with BERT. *CoRR* (2019).
- [34] Dae Hoon Park and Rikio Chiba. 2017. A Neural Language Model for Query Auto-Completion. In *SIGIR '17* (Shinjuku, Tokyo, Japan). Association for Computing Machinery, New York, NY, USA, 1189–1192. <https://doi.org/10.1145/3077136.3080758>
- [35] Taihua Shao, Honghui Chen, and Wanyu Chen. 2018. Query Auto-Completion Based on Word2vec Semantic Similarity. *Journal of Physics: Conference Series* 1004 (apr 2018), 012018. <https://doi.org/10.1088/1742-6596/1004/1/012018>
- [36] Milad Shokouhi. 2013. Learning to Personalize Query Auto-Completion. In *SIGIR '13* (Dublin, Ireland). ACM, New York, NY, USA, 103–112. <https://doi.org/10.1145/2484028.2484076>
- [37] Milad Shokouhi and Kira Radinsky. 2012. Time-Sensitive Query Auto-Completion. In *Proceedings of the 35th International ACM SIGIR Conference on Research and Development in Information Retrieval* (Portland, Oregon, USA) (*SIGIR '12*). Association for Computing Machinery, New York, NY, USA, 601–610. <https://doi.org/10.1145/2348283.2348364>
- [38] Ashish Vaswani, Noam Shazeer, Niki Parmar, Jakob Uszkoreit, Llion Jones, Aidan N Gomez, Łukasz Kaiser, and Illia Polosukhin. 2017. Attention is all you need. In *NeurIPS '17*. 5998–6008.
- [39] Ganesh Venkataraman, Abhimanyu Lad, Viet Ha-Thuc, and Dhruv Arya. 2016. Instant Search: A Hands-on Tutorial. In *SIGIR '16* (Pisa, Italy). ACM, 1211–1214.
- [40] Stewart Whiting and Joemon M. Jose. 2014. Recent and Robust Query Auto-Completion. In *WWW '14* (Seoul, Korea). Association for Computing Machinery, New York, NY, USA, 971–982. <https://doi.org/10.1145/2566486.2568009>
- [41] Hamed Zamani, Michael Bendersky, Xuanhui Wang, and Mingyang Zhang. 2017. Situational Context for Ranking in Personal Search. In *WWW '17* (Perth, Australia). 1531–1540.
- [42] Hamed Zamani, Mostafa Dehghani, W. Bruce Croft, Erik Learned-Miller, and Jaap Kamps. 2018. From Neural Re-Ranking to Neural Ranking: Learning a Sparse Representation for Inverted Indexing. In *CIKM '18* (Torino, Italy). 497–506.
- [43] Aston Zhang, Amit Goyal, Weize Kong, Hongbo Deng, Anlei Dong, Yi Chang, Carl A. Gunter, and Jiawei Han. 2015. AdaQAC: Adaptive Query Auto-Completion via Implicit Negative Feedback. In *SIGIR '15* (Santiago, Chile). Association for Computing Machinery, New York, NY, USA, 143–152. <https://doi.org/10.1145/2766462.2767697>
- [44] Ke Zhou, Ronan Cummins, Mounia Lalmas, and Joemon M. Jose. 2012. Evaluating Aggregated Search Pages. In *Proceedings of the 35th International ACM SIGIR Conference on Research and Development in Information Retrieval* (Portland, Oregon, USA) (*SIGIR '12*). Association for Computing Machinery, New York, NY, USA, 115–124. <https://doi.org/10.1145/2348283.2348302>