Online Evaluations for Everyone: Mr. DLib's Living Lab for Scholarly Recommendations

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Abstract. We introduce the first 'living lab' for scholarly recommender systems. This lab allows recommender-system researchers to conduct online evaluations of their novel algorithms for scholarly recommendations, i.e., recommendations for research papers, citations, conferences, research grants, etc. Recommendations are delivered through the living lab's API to platforms such as reference management software and digital libraries. The living lab is built on top of the recommender-system as-a-service Mr. DLib. Current partners are the reference management software JabRef and the CORE research team. We present the architecture of Mr. DLib's living lab as well as usage statistics on the first sixteen months of operating it. During this time, 1,826,643 recommendations were delivered with an average click-through rate of 0.21%.

Keywords: recommender system evaluation, living lab, online evaluation.

1 Introduction

'Living labs' for recommender systems enable researchers to evaluate their recommendation algorithms with real users in realistic scenarios. Such living labs – sometimes also called 'Evaluations-as-a-Service' [1-3] – are usually built on top of production recommender systems in real-world platforms such as news websites [4]. Via an API, external researchers can 'plug-in' their experimental recommender systems to the living lab. When recommendations for users of the platform are needed, the living lab sends a request to the researcher's experimental recommender system. This system then returns a list of recommendations that are displayed to the user. The user's actions (clicks, downloads, purchases, etc.) are logged and can be used to evaluate the recommendation algorithms' effectiveness.

Living labs are available in information retrieval and for many recommender-system domains, particularly news [4–6], and they attracted dedicated workshops [7]. There is also work on living labs in the context of search and browsing behavior in digital

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libraries [8]. However, to the best of our knowledge, there are no living labs for scholarly recommendations, i.e., recommendations for research articles [9,10], citations [11,12], conferences [13,14], reviewers [15,16], quotes [17], research grants, or collaborators [18]. Consequently, researchers in the field of scholarly recommender systems predominately rely on offline evaluations, which tend to be poor predictors of how algorithms will perform in a production recommender system [19,20].

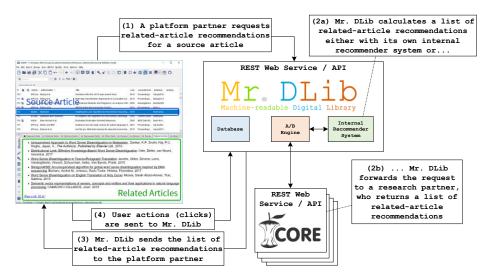
In this paper, we present the first living lab for scholarly recommendations, built on top of Mr. DLib, a scholarly recommendations-as-a-service provider [21,22]. Mr. DLib's main feature is to provide third parties such as digital libraries with recommendations for their users. This way, digital libraries do not need to maintain their own recommender system, which would usually be costly and require advanced skills in machine learning and recommender systems. So far, Mr. DLib relied only on its own recommender system to generate recommendations [21,22]. The system was not open to external researchers. The newly added living lab opens Mr. Lib and provides an environment for any researcher in the field of scholarly recommendations to evaluate novel recommendation algorithms with real users in addition to, or instead of, conducting offline evaluations.

2 Mr. DLib's Scholarly Living Lab

Mr. DLib's living lab is open for two types of partners. First, platform operators, who want to provide their users with scholarly recommendations. Second, research partners, who want to evaluate their novel scholarly recommendation algorithms with real users. The current platform partner of Mr. DLib is the reference-management software JabRef [23,24]. The current research partner of Mr. DLib is CORE [25–27]. Mr. DLib acts as an intermediate between these partners. Mr. DLib also operates its own internal recommendation engine, which applies content-based filtering with terms, key-phrases, and word embeddings as well as stereotype and most-popular recommendations [22,28]. Thus, Mr. DLib's internal recommendation engine establishes a baseline for research partners to compare their novel algorithms against.

The workflow of Mr. DLib's living lab is illustrated in **Fig. 1**: (1) A JabRef user selects a source article in the list, and then selects the "Related Articles" tab; JabRef sends a request to Mr. DLib's API. The request comprises of the selected article's title. Mr. DLib's API accepts the request, and its A/B engine randomly forwards the request either to (2a) Mr. DLib's internal recommender system or (2b) to CORE's recommender system. CORE or Mr. DLib's internal recommender system creates a list of recommendations and (3) returns them to JabRef, which displays them to the user. (4) When a user clicks a recommendation, a notification it sent to Mr. DLib for evaluation purposes.

While, currently, Mr. DLib only has one research and one platform partner, there will potentially be numerous such partners in the future. Mr. DLib's living lab is open to any research partner whose experimental recommender system recommends scholarly items; is available through a REST API; accepts a string as input (typically a source article's title); and returns a list of related-articles including URLs to web pages



on which the recommended articles can be downloaded, preferably open access. Also, recommendations must be returned within less than 2 seconds.

Fig. 1. Illustration of the recommendation process

All data on Mr. DLib's recommendations is available publicly [29]. This data can be used to replicate our calculations and perform additional analyses. JabRef's client software, including the recommender system, can be downloaded at <u>http://jabref.org</u>. Source code of the API is available on <u>http://mr-dlib.org</u>.

3 Usage Statistics

Mr. DLib started its general recommendation service in 2016 [21] and its living lab in June 2017. The living lab was integrated first in a beta version of JabRef. During the beta phase (until September 2017), JabRef sent around 4,200 requests per month to Mr. DLib (**Fig. 2**). For each request, Mr. DLib returned typically 6 recommendations (25k recommendations in total), whereas between 20% to 30% of the recommendation engine. Click-through rate (**CTR**) on the recommendations decreased from 0.76% in June to 0.34% in September (**Fig. 2**). After the beta phase, i.e., from October 2017 on, the number of delivered recommendations increased to around 150k per month, again with 20% to 30% of the recommendations generated by CORE. The overall click-through rate decreased to around 0.18% but remained stable until today.

We can only speculate why click-through rate decreased during the beta phase and decreased again in the stable version. Possibly, beta users are more curious than regular users. Maybe users generally are more curious in the beginning when a new feature is released. Maybe, recommendations worsen over time, or were simply not as good as users expected and hence users lose interest. However, we made the observation that

CTR decreases over time also on Mr. DLib's other partner platforms that do not participate in the living lab [22,28], as well as in other recommender systems [30].

Interestingly, click-through rates for both CORE and Mr. DLib's internal recommendation engine are almost identical over the entire data collection period. Both systems mostly use Apache Lucene for their recommendation engine, yet there are notable differences in the algorithms and document corpora. We will not elaborate further on the implementations but refer the interested reader to [22,27,28]. The interesting point here is that two separately implemented recommender systems perform almost identically. It is also interesting that the click-through rate in the reference management software JabRef (0.18%) is quite similar to the click-through rate in the social-science repository Sowiport [28,31–33], although the two platforms differ notably.

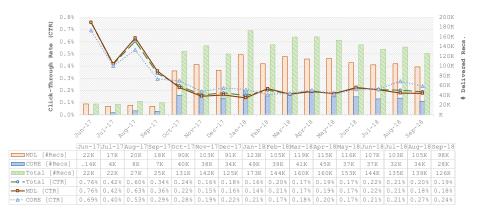


Fig. 2. Click-through rate (CTR) and # of delivered recommendation in JabRef for Mr. DLib's (MDL) and CORE's recommendation engine and in total.

4 Future Work

In the long-run, we hope to provide a platform to the information retrieval, digital library, and recommender systems community that helps conducting more reproducible and robust research in real-world scenarios [34,35]. To achieve this, we plan to add more partners on both sides – platform partners who provide access to real users, and research partners who evaluate their novel algorithms via the living lab. We also aim for personalized recommendations in addition to the current focus on related-article recommendations. We will also enable the recommendation of other scholarly items such as research grants, or research collaborators. We also plan to develop a more automatic process for the integration of partners, with standard protocols and data formats, and pre-implemented clients, to ease the process. Another major challenge in the future will be to select the best algorithms for each platform partner [36].

References

- A. Hanbury, H. Müller, K. Balog, T. Brodt, G.V. Cormack, I. Eggel, T. Gollub, F. Hopfgartner, J. Kalpathy-Cramer, N. Kando, and others, "Evaluation-as-a-Service: Overview and outlook," *arXiv preprint arXiv:1512.07454*, 2015.
- [2] F. Hopfgartner, A. Hanbury, H. Müller, N. Kando, S. Mercer, J. Kalpathy-Cramer, M. Potthast, T. Gollub, A. Krithara, J. Lin, and others, "Report on the Evaluation-as-a-Service (EaaS) expert workshop," ACM SIGIR Forum, ACM, 2015, pp. 57–65.
- [3] F. Hopfgartner, A. Hanbury, H. Müller, I. Eggel, K. Balog, T. Brodt, G.V. Cormack, J. Lin, J. Kalpathy-Cramer, N. Kando, and others, "Evaluation-as-a-Service for the Computational Sciences: Overview and Outlook," *Journal of Data and Information Quality (JDIQ)*, vol. 10, 2018, p. 15.
- [4] T. Brodt and F. Hopfgartner, "Shedding light on a living lab: the CLEF NEWSREEL open recommendation platform," *Proceedings of the 5th Information Interaction in Context Symposium*, ACM, 2014, pp. 223–226.
- [5] F. Hopfgartner, T. Brodt, J. Seiler, B. Kille, A. Lommatzsch, M. Larson, R. Turrin, and A. Serény, "Benchmarking news recommendations: The clef newsreel use case," ACM SIGIR Forum, ACM, 2016, pp. 129–136.
- [6] B. Kille, A. Lommatzsch, G.G. Gebremeskel, F. Hopfgartner, M. Larson, J. Seiler, D. Malagoli, A. Serény, T. Brodt, and A.P. De Vries, "Overview of newsreel'16: Multi-dimensional evaluation of real-time stream-recommendation algorithms," *International Conference of the Cross-Language Evaluation Forum for European Languages*, Springer, 2016, pp. 311–331.
- [7] K. Balog, D. Elsweiler, E. Kanoulas, L. Kelly, and M.D. Smucker, "Report on the CIKM workshop on living labs for information retrieval evaluation," ACM SIGIR Forum, ACM, 2014, pp. 21–28.
- [8] Z. Carevic, S. Schüller, P. Mayr, and N. Fuhr, "Contextualised Browsing in a Digital Library's Living Lab," *Proceedings of the 18th ACM/IEEE on Joint Conference on Digital Libraries*, Fort Worth, Texas, USA: ACM, 2018, pp. 89– 98.
- [9] S. Li, P. Brusilovsky, S. Su, and X. Cheng, "Conference Paper Recommendation for Academic Conferences," *IEEE Access*, vol. 6, 2018, pp. 17153–17164.
- [10] S. Vargas, M. Hristakeva, and K. Jack, "Mendeley: Recommendations for Researchers," *Proceedings of the 10th ACM Conference on Recommender Systems*, Boston, Massachusetts, USA: ACM, 2016, pp. 365–365.
- [11] M. Färber, A. Thiemann, and A. Jatowt, "CITEWERTs: A System Combining Cite-Worthiness with Citation Recommendation," *European Conference on Information Retrieval*, Springer, 2018, pp. 815–819.
- [12] H. Jia and E. Saule, "Graph Embedding for Citation Recommendation," *arXiv* preprint arXiv:1812.03835, 2018.
- [13] F. Beierle, J. Tan, and K. Grunert, "Analyzing social relations for recommending academic conferences," *Proceedings of the 8th ACM International Workshop on Hot Topics in Planet-scale mObile computing and online Social neTworking*, ACM, 2016, pp. 37–42.
- [14] S. Yu, J. Liu, Z. Yang, Z. Chen, H. Jiang, A. Tolba, and F. Xia, "PAVE: Personalized Academic Venue recommendation Exploiting co-publication

networks," *Journal of Network and Computer Applications*, vol. 104, 2018, pp. 38–47.

- [15] N.M. Kou, N. Mamoulis, Y. Li, Y. Li, Z. Gong, and others, "A topic-based reviewer assignment system," *Proceedings of the VLDB Endowment*, vol. 8, 2015, pp. 1852–1855.
- [16] J.W. Lian, N. Mattei, R. Noble, and T. Walsh, "The conference paper assignment problem: Using order weighted averages to assign indivisible goods," *Thirty-Second AAAI Conference on Artificial Intelligence*, 2018.
- [17] J. Tan, X. Wan, H. Liu, and J. Xiao, "QuoteRec: Toward Quote Recommendation for Writing," ACM Transactions on Information Systems (TOIS), vol. 36, 2018, p. 34.
- [18] X. Kong, H. Jiang, W. Wang, T.M. Bekele, Z. Xu, and M. Wang, "Exploring dynamic research interest and academic influence for scientific collaborator recommendation," *Scientometrics*, vol. 113, 2017, pp. 369–385.
- [19] G. de S.P. Moreira, G.A. de Souza, and A.M. da Cunha, "Comparing Offline and Online Recommender System Evaluations on Long-tail Distributions.," *Proceedings of the ACM Recommender Systems Conference RecSys*, 2015.
- [20] M. Rossetti, F. Stella, and M. Zanker, "Contrasting Offline and Online Results when Evaluating Recommendation Algorithms," *Proceedings of the 10th ACM Conference on Recommender Systems*, Boston, Massachusetts, USA: ACM, 2016, pp. 31–34.
- [21] J. Beel, A. Aizawa, C. Breitinger, and B. Gipp, "Mr. DLib: Recommendationsas-a-service (RaaS) for Academia," *Proceedings of the 17th ACM/IEEE Joint Conference on Digital Libraries*, Toronto, Ontario, Canada: IEEE Press, 2017, pp. 313–314.
- [22] J. Beel, A. Collins, and A. Aizawa, "The Architecture of Mr. DLib's Scientific Recommender-System API," *Proceedings of the 26th Irish Conference on Artificial Intelligence and Cognitive Science (AICS)*, CEUR-WS, 2018, pp. 78– 89.
- [23] S. Feyer, S. Siebert, B. Gipp, A. Aizawa, and J. Beel, "Integration of the Scientific Recommender System Mr. DLib into the Reference Manager JabRef," *Proceedings of the 39th European Conference on Information Retrieval (ECIR)*, 2017, pp. 770–774.
- [24] O. Kopp, U. Breitenbuecher, and T. Mueller, "CloudRef Towards Collaborative Reference Management in the Cloud," *Proceedings of the 10th Central European Workshop on Services and their Composition*, 2018.
- [25] M. Hristakeva, D. Kershaw, M. Rossetti, P. Knoth, B. Pettit, S. Vargas, and K. Jack, "Building recommender systems for scholarly information," *Proceedings of the 1st Workshop on Scholarly Web Mining*, ACM, 2017, pp. 25–32.
- [26] P. Knoth, L. Anastasiou, A. Charalampous, M. Cancellieri, S. Pearce, N. Pontika, and V. Bayer, "Towards effective research recommender systems for repositories," *Proceedings of the Open Repositories Conference*, 2017.
- [27] N. Pontika, L. Anastasiou, A. Charalampous, M. Cancellieri, S. Pearce, and P. Knoth, "CORE Recommender: a plug in suggesting open access content," http://hdl.handle.net/1842/23359, 2017.
- [28] J. Beel, S. Dinesh, P. Mayr, Z. Carevic, and J. Raghvendra, "Stereotype and Most-Popular Recommendations in the Digital Library Sowiport," *Proceedings*

of the 15th International Symposium of Information Science (ISI), 2017, pp. 96–108.

- [29] J. Beel, B. Smyth, and A. Collins, "RARD II: The 94 Million Related-Article Recommendation Dataset," *Proceedings of the 1st Interdisciplinary Workshop* on Algorithm Selection and Meta-Learning in Information Retrieval (AMIR), CEUR-WS, 2019, pp. 39–55.
- [30] J. Beel, S. Langer, B. Gipp, and A. Nuernberger, "The Architecture and Datasets of Docear's Research Paper Recommender System," *D-Lib Magazine*, vol. 20, 2014.
- [31] D. Hienert, F. Sawitzki, and P. Mayr, "Digital library research in action - supporting information retrieval in Sowiport," *D-Lib Magazine*, vol. 21, 2015.
- [32] P. Mayr, "Sowiport User Search Sessions Data Set (SUSS)," *GESIS Datorium*, 2016.
- [33] M. Stempfhuber, P. Schaer, and W. Shen, "Enhancing visibility: Integrating grey literature in the SOWIPORT Information Cycle," *International Conference* on Grey Literature, 2008, pp. 23–29.
- [34] J. Beel, C. Breitinger, S. Langer, A. Lommatzsch, and B. Gipp, "Towards Reproducibility in Recommender-Systems Research," *User Modeling and User-Adapted Interaction (UMUAI)*, vol. 26, 2016, pp. 69–101.
- [35] N. Ferro, N. Fuhr, and A. Rauber, "Introduction to the Special Issue on Reproducibility in Information Retrieval: Tools and Infrastructures," *Journal of Data and Information Quality (JDIQ)*, vol. 10, 2018, p. 14.
- [36] A. Collins, D. Tkaczyk, and J. Beel, "A Novel Approach to Recommendation Algorithm Selection using Meta-Learning," *Proceedings of the 26th Irish Conference on Artificial Intelligence and Cognitive Science (AICS)*, CEUR-WS, 2018, pp. 210–219.