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Preface to the special issue on dynamic recommender systems and user models

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1 Introduction

The ever-growing and dynamic nature of user-generated data in online systems poses obvious challenges on how we learn from such data. The underlying problem is how to adapt, in real time, to multiple simultaneous changes involving individual users, user contexts and the system as a whole. Many algorithms are able to adjust their output to some of these changes in real time; however, this requires that the model has been previously trained on data with very similar phenomena. To adapt to new trends, preferences and other unpredictable phenomena, algorithms must be able to update the underlying model itself, which should preferably happen online, incrementally and in real time. This motivates the research on adaptive methods able to maintain and evolve predictive models over time. Incremental learning algorithms and data stream mining have gained maturity in recent years. However, this body of knowledge has not been applied to predictive user modeling, and although the potential to solve relevant problems is high, advances in this direction are far from trivial, calling for further research in this direction.

This special issue provides contributions on the above challenges, explored and discussed in the Online Recommender Systems and User Modeling (ORSUM) workshop series that have taken place since 2018 in The Web Conference 2018 (Jorge et al. 2018) and the ACM Conference on Recommender Systems between 2019 and 2022 (Vinagre et al. 2019, 2020, 2021).

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2 Papers in this issue

The 7 contributions in the special issue involve topics related to online bandits, incremental/online machine learning, ranking aggregation, cold-start, session-based and sequential recommendation.

Embarrassingly shallow auto-encoders for dynamic collaborative filtering (Jeunen et al. 2022) presents a method to incrementally update models based on EASE^{R} (Steck 2019), a state-of-the-art method to efficiently train large recommendation models. In their proposal, Jeunen et al. exploit the assumption of low-rank of the user-item interaction matrix, which allows the learning algorithm to target only parts of the model that require updating, as new feedback is received from users.

Scalable stream-based recommendations with random walks on incremental graph of sequential interactions with implicit feedback (Schmitt and Spinosa 2022) propose an incremental algorithm—$\text{ISGI}_{\hat{\pi}^t}$—that models personalized interaction sequences in an item graph from implicit user feedback streams. Recommendations are obtained by performing simulations of short random walks in the obtained graph. This article extends the work presented at the 4th Workshop on Online Recommender Systems and User Modeling (Schmitt and Spinosa 2020).

Dynamic session-based music recommendation using information retrieval techniques (Tofani et al. 2022) addresses session-based music recommendation with three algorithms inspired by classic information retrieval techniques—two based on TF-IDF and one on Markov Chains. All three algorithms share the ability to update models incrementally with new user-item interactions received by the system.

Dirichlet–Luce choice model for learning from interactions (Çapan et al. 2022) proposes a Bayesian choice model, leading to an online bandit algorithm able to efficiently learn from user interactions, while simultaneously dealing with biases that typically penalize underexposed or underrepresented items in online recommender systems.

Online convex combination of ranking models (Frigó and Kocsis 2021) addresses the complex task of combining rankings from diverse recommenders online. The authors extend a previous contribution at the 14th ACM Conference on Recommender Systems (Frigó and Kocsis 2019), where they presented RFDSA+—an extension to RFDSA (Kocsis and Szepesvári 2006)—introducing with LAG, an algorithm with stronger theoretical guarantees.

Rank-sensitive proportional aggregations in dynamic recommendation scenarios (Balcar et al. 2022) is an extension of the authors' work presented at the 3rd Workshop on Online Recommender Systems and User Modeling (Peska and Balcar 2019). The contribution consists of FuzzDA, an unbiased online rank aggregation framework that relies on proportionality provided by a modified D'Hont's algorithm for proportional mandates allocation.

NFC: a deep and hybrid item-based model for item cold-start recommendation (Bernardis and Cremonesi 2021) contributes with *Neural Feature Combiner* (NFC), a hybrid item-based algorithm to deal with item cold-start. The algorithm combines content features with collaborative information in a common low-dimensional embedding space and uses a deep neural network to learn item similarity values. The authors

experiment with several variants of the algorithm under extreme and mild cold-start conditions, with state-of-the-art predictive performance.

3 Outlook

The recent growing interest of the community on models able to learn online has happened in two separate research directions. The first is the adoption of methods developed in the context of data stream mining to recommender systems. The philosophy of this approach is to look at data not as a monolithic block that, when processed by a learning algorithm, produces a static model, but rather as a stream of incoming data that is continually processed, producing an ever-evolving model. Another increasingly prominent direction is the application of online learning algorithms based on multi-armed bandits and reinforcement learning. The perspective here is that models do not exist in isolation, but are part of an interactive system from which they continuously learn. These two paths have been researched mostly in separation so far; however, we foresee that they may merge in the near future, given their complementarity and common challenges, regarding learning algorithms—e.g., bandit models require online updating—implementation and evaluation.

One fundamental step forward is online evaluation and monitoring. Classic evaluation methodologies from machine learning and information retrieval are barely applicable to online learning methods, simply because there is not *one* model to evaluate, but a continual learning process instead. This requires novel robust evaluation frameworks for trustworthy recommender systems that can be applied online, involving multidimensional evaluation criteria and specialized metrics for recommendation accuracy, fairness, privacy and explainability.

Finally, we believe that online methods will continue to be studied and gradually adopted by practitioners. The trend will naturally lead to the systematic application of online methods in user modeling, recommendation and personalization, converging into increasingly trustworthy, autonomous and continual learning environments, where static and online models co-exist and are trained, combined and monitored online.

References

Balcar, S., Skrhak, V., Peska, L.: Rank-sensitive proportional aggregations in dynamic recommendation scenarios. User Model. User-Adapt. Interact. (2022). https://doi.org/10.1007/s11257-021-09311-w

Bernardis, C., Cremonesi, P.: NFC: a deep and hybrid item-based model for item cold-start recommendation. User Model. User Adap. Interact. (2021). https://doi.org/10.1007/s11257-021-09303-w

Çapan, G., Gündoğdu, İ, Türkmen, A.C., et al.: Dirichlet-luce choice model for learning from interactions. User Model. User Adapt. Interact. (2022). https://doi.org/10.1007/s11257-022-09331-0

Frigó, E., Kocsis, L.: Online ranking combination. In: Bogers, T., Said, A., Brusilovsky, P., et al. (eds) Proceedings of the 13th ACM Conference on Recommender Systems, RecSys 2019, Copenhagen, Denmark, September 16-20, 2019. ACM, pp 12–19 (2019), https://doi.org/10.1145/3298689.3346993

Frigó, E., Kocsis, L.: Online convex combination of ranking models. User Model. User-Adapt. Interact. (2021). https://doi.org/10.1007/s11257-021-09306-7

Jeunen, O., Van Balen, J., Goethals, B.: Embarrassingly shallow auto-encoders for dynamic collaborative filtering. User Model. User Adapt. Interact. (2022). https://doi.org/10.1007/s11257-021-09314-7

Jorge, A., Vinagre, J., Matuszyk, P., et al.: ORSUM chairs' welcome & organization. In: Champin, P., Gandon, F., Lalmas, M., et al. (eds) Companion of the The Web Conference 2018 on The Web Conference 2018, WWW 2018, Lyon , France, April 23-27, 2018. ACM, pp 1365–1366 (2018), https://doi.org/10.1145/3184558.3192311

Kocsis, L., Szepesvári, C.: Universal parameter optimisation in games based on SPSA. Mach. Learn. **63**(3), 249–286 (2006). https://doi.org/10.1007/s10994-006-6888-8

Peska, L., Balcar, S.: Fuzzy d'hondt's algorithm for on-line recommendations aggregation. In: Vinagre, J., Jorge, A.M., Bifet, A., et al. (eds) 2nd Workshop on Online Recommender Systems and User Modeling, ORSUM@RecSys 2019, 19 September 2019, Copenhagen, Denmark, Proceedings of Machine Learning Research, vol 109. PMLR, pp 2–11 (2019), http://proceedings.mlr.press/v109/peska19a.html

Schmitt, M.F.L., Spinosa, E.J.: Incremental graph of sequential interactions for online recommendation with implicit feedback. In: Vinagre, J., Jorge, A.M., Al-Ghossein, M., et al. (eds) Proceedings of the 3rd Workshop on Online Recommender Systems and User Modeling co-located with the 14th ACM Conference on Recommender Systems (RecSys 2020), Virtual Event, September 25, 2020, CEUR Workshop Proceedings, vol 2715. CEUR-WS.org, (2020) http://ceur-ws.org/Vol-2715/paper10.pdf

Schmitt, M.F.L., Spinosa, E.J.: Scalable stream-based recommendations with random walks on incremental graph of sequential interactions with implicit feedback. User Modeling and User-Adapted Interaction (2022). https://doi.org/10.1007/s11257-021-09315-6

Steck, H.: Embarrassingly shallow autoencoders for sparse data. In: Liu, L., White, R.W., Mantrach, A., et al. (eds) The World Wide Web Conference, WWW 2019, San Francisco, CA, USA, May 13-17, 2019. ACM, pp 3251–3257 (2019), https://doi.org/10.1145/3308558.3313710

Tofani, A., Borges, R., Queiroz, M.: Dynamic session-based music recommendation using information retrieval techniques. User Modeling and User-Adapted Interaction (2022).https://doi.org/10.1007/s11257-022-09343-w

Vinagre, J., Jorge, A.M., Bifet, A., et al.: ORSUM 2019 2nd workshop on online recommender systems and user modeling. In: Bogers, T., Said, A., Brusilovsky, P., et al. (eds) Proceedings of the 13th ACM Conference on Recommender Systems, RecSys 2019, Copenhagen, Denmark, September 16-20, 2019. ACM, pp 562–563 (2019), https://doi.org/10.1145/3298689.3347057

Vinagre, J., Jorge, A.M., Al-Ghossein, M., et al.: ORSUM - workshop on online recommender systems and user modeling. In: Santos, R.L.T., Marinho, L.B., Daly, E.M., et al. (eds) RecSys 2020: Fourteenth ACM Conference on Recommender Systems, Virtual Event, Brazil, September 22-26, 2020. ACM, pp 619–620 (2020), https://doi.org/10.1145/3383313.3411531

Vinagre, J., Jorge, A.M., Al-Ghossein, M., et al.: ORSUM 2021 - 4th workshop on online recommender systems and user modeling. In: Pampín, H.J.C., Larson, M.A., Willemsen, M.C., et al. (eds) RecSys '21: Fifteenth ACM Conference on Recommender Systems, Amsterdam, The Netherlands, 27 September 2021 - 1 October 2021. ACM, pp 792–793 (2021), https://doi.org/10.1145/3460231.3470940

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