Paradigm Shifts in User Modeling: A Journey from Historical Foundations to Emerging Trends

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ABSTRACT

The presented tutorial aims to serve as a comprehensive roadmap for the UMAP community into the current user modeling research, focusing on the *paradigm shifts* that have transformed the research landscape in recent times. We will provide a complete overview of the large, long-standing, and ever-growing research fields of user modeling and user profiling, both from a historical and a technical point of view. We will then examine the definitions associated with each key term in this research domain, aiming to eliminate ambiguity and confusion in their usage. As the core of our tutorial, we present in-depth the paradigm shifts that have occurred in recent years, especially due to technological evolution, as well as the current research directions and novel trends in the field. In particular, we illustrate and discuss the advances in the following topics: implicit and explicit user profiling, user behavior modeling, user representation, and beyond-accuracy perspectives. The audience will be engaged in discussions during the whole presentation to foster the development of an interactive event.

Detailed information and resources about the tutorial are available on the website: https://link.erasmopurif.com/tutorial-umap24.

CCS CONCEPTS

• **Human-centered computing** → **User models**; • **Social and professional topics** → **User characteristics**; • **Applied computing** → **Law, social and behavioral sciences**.

KEYWORDS

User Modeling, User Profiling, Paradigm Shifts

1 MOTIVATION

In the era dominated by artificial intelligence (AI) systems, the integration of such technologies into daily life is unavoidable, whether consciously embraced or not. Specifically, in the realm of widely adopted tools, information retrieval (IR) and recommendation systems (RSs) efficiently deliver relevant information to users based on their information needs, personality traits, and contextual cues. In an environment where daily interactions with these systems generate a substantial amount of personal data, the necessity to understand individuals' interests, characteristics, and behaviors is met through the use of user modeling and profiling techniques [8]. These techniques primarily aim to construct a dependable user representation, such as a user model or user profile, derived from generated data [12]. User modeling and profiling play a crucial role in comprehending user behavior and providing personalized experiences. Organizations can glean valuable insights into individual preferences and interests by analyzing user data, encompassing browsing history, purchase patterns, and social interactions. Consequently, this facilitates the delivery of tailored content, products, and services, ultimately elevating user satisfaction and engagement.

The presented tutorial is concretely based on **our comprehensive survey** [18]. It embarks on an exploration of the expansive domain of user modeling research, with a primary focus on uncovering the **paradigm shifts** that happened in essential areas of the field. Initiating the journey with an examination of *historical foundations*, we delve into the evolution of user modeling, revealing key milestones and pivotal moments that have shaped the field (e.g., [4, 7, 14, 21]).

Moving forward, we navigate the intricate web of *terminology and definitions* that have emerged over the years, fostering a comprehensive understanding and dispelling confusion prevalent in the literature [3, 9, 10].

As the journey progresses, we shed light on *paradigm shifts* that have dynamically reshaped the research landscape in recent years. Through analytical exploration, insights into the transformative forces influencing user modeling methodologies and approaches are shown. In particular, we discuss: how recent studies have adopted solely *implicit* approaches [12] for user data collection and true *explicit* profiling [3] have been replaced by a sort of *pseudo-explicit* profiling [16]; the evolution of *user behavior modeling* [5, 6]; the advent and diffusion of the concepts of *universal user representation* [13, 22].
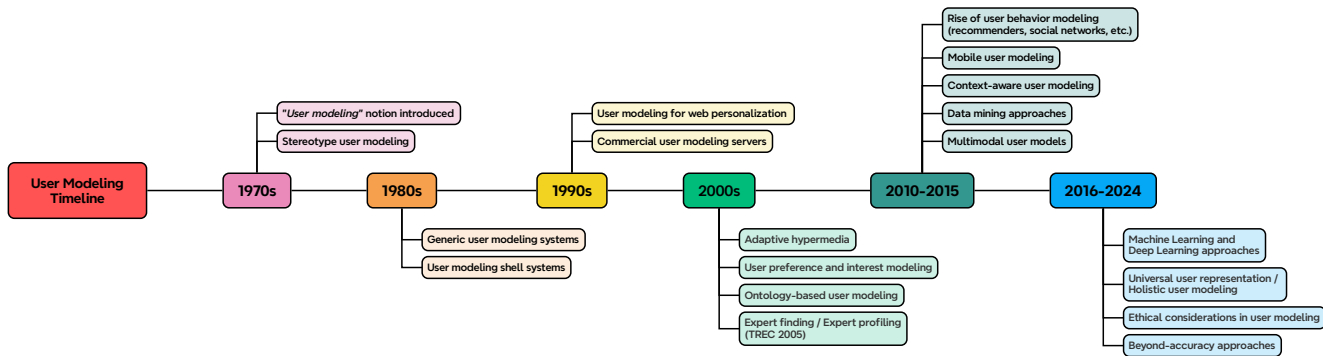
Figure 1: Timeline reporting the major events of the user modeling history (from [18]).

Finally, our tutorial directs attention to the horizon of user modeling research, unveiling *emerging trends* that shape the field's future, such as the contributions on *beyond-accuracy perspectives* (e.g., *explainability* [2, 11], *fairness* [1, 17, 19], and *privacy* [15, 20]) and *human-AI collaboration* [23]. By examining these trends, a readiness to navigate the evolving landscape and anticipate the trajectories defining the forefront of user modeling in the coming years is stimulated.

In essence, our tutorial serves as a comprehensive roadmap into the current user modeling research for the whole UMAP community. Participants at the tutorial will be well-equipped to comprehend the historical foundations of user modeling research, analyze the diverse terminology and definitions that have evolved over the years, and discern paradigmatic shifts that have redefined the research landscape. Additionally, they will be prepared to anticipate and embrace emerging trends, ensuring they stay at the forefront of user modeling advancements.

2 TARGETED AUDIENCE

Our tutorial warmly welcomes researchers, practitioners, and professionals within the UMAP community, as well as those exploring the broader field of user modeling, and it is suitable for participants with varying levels of experience, from beginners to experts. The tutorial is intended for any audience and is open to researchers, industry technologists, and practitioners. No specific prerequisites are required to participate in this tutorial. The content is structured to be accessible to a diverse audience, including those new to the user modeling field. It is also worth noticing that the concepts illustrated during the tutorial and their applications touch a range of interdisciplinary fields, making the proposed tutorial of interest to an interdisciplinary audience.

3 OUTLINE

The tutorial is designed to provide a comprehensive exploration of key aspects of the user modeling landscape. The intended length is **90 minutes** (i.e., one hour and a half). Here is an overview of the expected outline:

- **Opening and welcome** (5 mins)
  - Brief overview of the tutorial objectives

  - Introduction of the presenters
- **Historical overview of user modeling research** (15 mins)
  - Journey through the historical foundations of the user modeling domain;
  - Exploration of the key milestones and pivotal moments shaping the field as shown in Figure 1.
- **Terminological analysis in user modeling** (15 mins)
  - Navigation through prevalent terminology in recent user modeling literature;
  - Critical examination and clarification of key concepts of the domain.
- **Paradigm shifts in recent years** (25 mins)
  - Exploration of the significant paradigm shifts in user modeling research;
  - Examination of the technological advancements and novel research approaches.
- **Emerging trends in user modeling** (20 mins)
  - Analysis of the latest trends forging the future of the user modeling research area.
- **Q&A and discussion** (10 mins)
  - Time for participants to ask questions and engage in discussions;
  - Summary of key takeaways.

4 TUTORIAL ORGANIZERS

Erasmo Purificato (webpage: https://erasmopurif.com/; email: erasmo.purificato@acm.org) has been a Research Assistant in the "Human-Centred AI" group at the Otto von Guericke University Magdeburg since February 2020, where he is doing a Ph.D. in Computer Science with a project about fairness analysis of Graph Neural Networks for behavioral user profiling focusing. From February 2020 to June 2024, he was a Research Fellow in the "Human-Centred Technologies for Educational Media" department at the Leibniz Institute for Educational Media | Georg Eckert Institute (GEI), based in Brunswick. From July 2021 he has been appointed by the Guglielmo Marconi University of Rome, Italy, as an Adjunct Professor in "Software Engineering". He has already given tutorials on fairness, user modeling, and GNNs at UMAP '23 and CIKM '23. He also co-organized several workshops and summer

schools, such as APEx-UI at IUI '22, HCAI4U at CHIItaly '23, XAI.it at AIxIA '23, IRonGraphs at ECIR '24, and the IEEE Autumn School ISACT co-located with ICHMS '22. He has been part of the program committee of several conferences and workshops, such as SIGIR, CIKM, RecSys, UMAP, HT and ExUM, and served as a reviewer for journals, such as TORS, TOIS, TITS, and KNOSYS.

Ludovico Boratto (webpage: https://www.ludovicoboratto.com/; email: ludovico.boratto@acm.org) is an Assistant Professor at the Department of Mathematics and Computer Science of the University of Cagliari (Italy). His research interests focus on recommender systems and their impact on stakeholders. He has authored more than 60 papers and published his research in top-tier conferences and journals. His research activity brought him to give talks and tutorials at top-tier conferences and research centres. He is the editor of the book "Group Recommender Systems: An Introduction" by Springer. He is an editorial board member of the "Information Processing & Management" journal (Elsevier) and "Journal of Intelligent Information Systems" (Springer), and guest editor of several journals' special issues. He is part of the program committees of the main Web conferences, where he received four outstanding contribution awards. He has given several tutorials in top-tier conferences, including RecSys 2022, ICDE 2021, ECIR 2021, WSDM 2021, ICDM 2020, UMAP 2020, DSAA 2018, ICDM 2017, RecSys 2016, ECAI 2016, and ECIR 2016. In 2012 he got his Ph.D. at the University of Cagliari. From May 2016 to April 2021, he joined Eurecat as Senior Research Scientist in the Data Science and Big Data Analytics research group. In 2010 and 2014, he spent ten months at Yahoo! Research in Barcelona as a visiting researcher. He is a member of ACM and IEEE.

Ernesto William De Luca (webpage: https://ernestodeluca.eu/; email: deluca@gei.de) is head of the "Human-Centred Technologies for Educational Media" department at the Leibniz Institute for Educational Media | Georg Eckert Institute (GEI) and from October 2019 has been appointed as a Full Professor in "Research Infrastructures for Digital Humanities" at the Otto von Guericke University Magdeburg, Germany. In addition, in May 2015, the Guglielmo Marconi University of Rome appointed him an associate professor in "Computational Engineering". He studied computational linguistics and then gained his Ph.D. in computer science. His research includes machine learning, human-machine interaction, Natural Language Processing, user and data modelling, the Semantic Web and Information Retrieval. He has written over 100 papers for national and international conferences and journals and organized and chaired numerous workshops and conferences. He is a regular reviewer and programme committee member of different high-profile journals and conferences.

REFERENCES

[1] Mohamed Abdelrazek, Erasmo Purificato, Ludovico Boratto, and Ernesto William De Luca. 2023. FairUP: A Framework for Fairness Analysis of Graph Neural Network-Based User Profiling Models. In *Proceedings of the 46th International ACM SIGIR Conference on Research and Development in Information Retrieval (SIGIR '23)*. Association for Computing Machinery, New York, NY, USA, 3165–3169. https://doi.org/10.1145/3539618.3591814

[2] Krisztian Balog, Filip Radlinski, and Shushan Arakelyan. 2019. Transparent, Scrutable and Explainable User Models for Personalized Recommendation. In *Proceedings of the 42nd International ACM SIGIR Conference on Research and Development in Information Retrieval*. ACM, Paris France, 265–274. https://doi.org/10.1145/3331184.3331211

[3] Peter Brusilovski, Alfred Kobsa, and Wolfgang Nejdl. 2007. *The Adaptive Web: Methods and Strategies of Web Personalization.* Springer Science & Business Media.

[4] Peter Brusilovsky, Alfred Kobsa, and Julita Vassileva (Eds.). 1998. *Adaptive Hypertext and Hypermedia.* Springer Netherlands, Dordrecht. https://link.springer.com/10.1007/978-94-017-0617-9

[5] Zhiyong Cheng, Sai Han, Fan Liu, Lei Zhu, Zan Gao, and Yuxin Peng. 2023. Multi-Behavior Recommendation with Cascading Graph Convolution Networks. In *Proceedings of the ACM Web Conference 2023 (WWW '23)*. Association for Computing Machinery, New York, NY, USA, 1181–1189. https://doi.org/10.1145/3543507.3583439

[6] Junsu Cho, Dongmin Hyun, Dong won Lim, Hyeon jae Cheon, Hyoung-iel Park, and Hwanjo Yu. 2023. Dynamic Multi-Behavior Sequence Modeling for Next Item Recommendation. *Proceedings of the AAAI Conference on Artificial Intelligence* 37, 4 (June 2023), 4199–4207. https://doi.org/10.1609/aaai.v37i4.25537

[7] Nick Craswell, Arjen de Vries, and Ian Soboroff. 2005. Overview of the TREC-2005 enterprise track.

[8] Christopher Ifeanyi Eke, Azah Anir Norman, Liyana Shuib, and Henry Friday Nweke. 2019. A Survey of User Profiling: State-of-the-Art, Challenges, and Solutions. *IEEE Access* 7 (2019), 144907–144924. https://doi.org/10.1109/ACCESS.2019.2944243

[9] Min Gao, Kecheng Liu, and Zhongfu Wu. 2010. Personalisation in web computing and informatics: Theories, techniques, applications, and future research. *Information Systems Frontiers* 12, 5 (Nov. 2010), 607–629. https://doi.org/10.1007/s10796-009-9199-3

[10] Daniela Godoy and Analia Amandi. 2005. User profiling in personal information agents: a survey. *The Knowledge Engineering Review* 20, 4 (Dec. 2005), 329–361. https://doi.org/10.1017/S0269888906000397

[11] Xiaowen Huang, Quan Fang, Shengsheng Qian, Jitao Sang, Yan Li, and Changsheng Xu. 2019. Explainable Interaction-driven User Modeling over Knowledge Graph for Sequential Recommendation. In *Proceedings of the 27th ACM International Conference on Multimedia (MM '19)*. Association for Computing Machinery, New York, NY, USA, 548–556. https://doi.org/10.1145/3343031.3350893

[12] Sumitkumar Kanoje, Sheetal Girase, and Debajyoti Mukhopadhyay. 2015. User Profiling Trends, Techniques and Applications. https://doi.org/10.48550/arXiv.1503.07474

[13] Sein Kim, Namkyeong Lee, Donghyun Kim, Minchul Yang, and Chanyoung Park. 2023. Task Relation-aware Continual User Representation Learning. In *Proceedings of the 29th ACM SIGKDD Conference on Knowledge Discovery and Data Mining (KDD '23)*. Association for Computing Machinery, New York, NY, USA, 1107–1119. https://doi.org/10.1145/3580305.3599516

[14] Alfred Kobsa. 2001. Generic User Modeling Systems. *User Modeling and User-Adapted Interaction* 11, 1 (March 2001), 49–63. https://doi.org/10.1023/A:1011187500863

[15] Sichun Luo, Yuanzhang Xiao, and Linqi Song. 2022. Personalized Federated Recommendation via Joint Representation Learning, User Clustering, and Model Adaptation. In *Proceedings of the 31st ACM International Conference on Information & Knowledge Management*. ACM, Atlanta GA USA, 4289–4293. https://doi.org/10.1145/3511808.3557660

[16] Zhengyi Ma, Zhicheng Dou, Yutao Zhu, Hanxun Zhong, and Ji-Rong Wen. 2021. One Chatbot Per Person: Creating Personalized Chatbots based on Implicit User Profiles. In *Proceedings of the 44th International ACM SIGIR Conference on Research and Development in Information Retrieval*. ACM, Virtual Event Canada, 555–564. https://doi.org/10.1145/3404835.3462828

[17] Erasmo Purificato, Ludovico Boratto, and Ernesto William De Luca. 2022. Do Graph Neural Networks Build Fair User Models? Assessing Disparate Impact and Mistreatment in Behavioural User Profiling. In *Proceedings of the 31st ACM International Conference on Information & Knowledge Management (CIKM '22)*. Association for Computing Machinery, New York, NY, USA, 4399–4403. https://doi.org/10.1145/3511808.3557584

[18] Erasmo Purificato, Ludovico Boratto, and Ernesto William De Luca. 2024. User Modeling and User Profiling: A Comprehensive Survey. https://doi.org/10.48550/arXiv.2402.09660

[19] Erasmo Purificato and Ernesto William De Luca. 2023. What Are We Missing in Algorithmic Fairness? Discussing Open Challenges for Fairness Analysis in User Profiling with Graph Neural Networks. In *Advances in Bias and Fairness in Information Retrieval (Communications in Computer and Information Science)*, Ludovico Boratto, Stefano Faralli, Mirko Marras, and Giovanni Stilo (Eds.). Springer Nature Switzerland, Cham, 169–175. https://doi.org/10.1007/978-3-031-37249-0_14

[20] Frederic Raber and Antonio Krüger. 2022. Transferring recommendations through privacy user models across domains. *User Modeling and User-Adapted Interaction* 32, 1 (April 2022), 25–90. https://doi.org/10.1007/s11257-021-09307-6

[21] Silvia Schiaffino and Analía Amandi. 2009. Intelligent User Profiling. In *Artificial Intelligence An International Perspective: An International Perspective*, Max Bramer (Ed.). Springer, Berlin, Heidelberg, 193–216. https://doi.org/10.1007/978-3-642-03226-4_11

[22] Fajie Yuan, Guoxiao Zhang, Alexandros Karatzoglou, Joemon Jose, Beibei Kong, and Yudong Li. 2021. One Person, One Model, One World: Learning Continual

User Representation without Forgetting. In *Proceedings of the 44th International ACM SIGIR Conference on Research and Development in Information Retrieval*. ACM, Virtual Event Canada, 696–705. https://doi.org/10.1145/3404835.3462884

[23] Mustafa Mert Çelikok, Pierre-Alexandre Murena, and Samuel Kaski. 2023. Modeling needs user modeling. *Frontiers in Artificial Intelligence* 6 (2023). https://doi.org/10.3389/frai.2023.1097891