UDC 004.7 **doi: 10.26906/SUNZ.2024.1.115**

Andrii Kuliahin

National Aerospace University named after M.E. Zhukovsky "KHAI", Kharkiv, Ukraine

PERSONALIZATION OF VISUAL CONTENT OF INTERACTIVE ART IN AUGMENTED REALITY BASED ON INDIVIDUAL USER PREFERENCES

Abstract. Topicality. In connection with the development of AR technologies and their use in interactive art, there is a growing need to develop methods of personalizing visual content, focused on the individual preferences of users. **Research methods.** Neural collaborative filtering method, generalized matrix factorization method, mood analysis on video. **The purpose of the article**: Researching the possibilities of improving the personalization of visual content in interactive art by evaluating the emotional reactions of users and their implicit feedback. **The results obtained.** The application of neural collaborative filtering and generalized matrix factorization to create adapted visual content in interactive art in AR was considered, which will significantly increase the relevance and immersion of users in interactive works. **Conclusion.** The considered approach can be used to improve immersiveness and personalization during user interaction with interactive art in AR.

Keywords: interactive art, augmented reality, neural collaborative filtering, generalized matrix factorization.

Introduction

The development of augmented reality (AR) technologies and their application in interactive art [1] opens new opportunities for personalization of visual content. Personalization becomes the basis for creating a deeper and more meaningful experience for users, allowing art to adapt to individual preferences and emotional states [2]. However, there are often problems with improving the immersion effect during user interaction with interactive art in augmented reality systems.

This article focuses on the novelty of the content personalization approach through the use of recommender systems based on implicit user feedback and the analysis of the user's mood expressed in the video (Video Sentiments Analysis) to improve the quality of personalization.

One of the aspects of improving the effect of immersion in art systems is the adaptation of content and interface to the needs and preferences of the user. In particular, the use of implicit feedback to the user can contribute to increasing the immersion effect and simplifying the user interface. Meanwhile, oversaturation of the system with explicit feedback can reduce the level of immersion and overload the interface [3, 4].

Implementation of a comprehensive approach to the personalization of visual content in interactive art, based on the application of Neural Collaborative Filtering (NCF) and Generalized Matrix Factorization (GMF) for processing user feedbacks. This approach allows taking into account not only the explicit choices and preferences of users, but also implicit signals such as emotional reactions and behavioral patterns during interaction with art objects. This depth of analysis is a significant advance in the field of personalized interaction, as it paves the way for creating unique, emotionally resonant experiences for each user.

In addition, the innovativeness of the research is emphasized by the use of Video Sentiments Analysis algorithms for a detailed study of the emotional reactions of users to visual content. This allows not only to improve the accuracy of the system's recommendations, but also to provide a deeper understanding of the emotional impact of art on an individual. Thus, the research makes a significant contribution to the development of personalized technologies in the field of augmented reality, opening new perspectives for interactive art.

The purpose of the article: the idea of this article is a detailed analysis and discussion of methods of personalization of visual content in interactive art in AR, with an emphasis on the use of implicit user feedback and Video Sentiments Analysis (VSA).

We aim to show how these approaches can significantly improve the user experience, making artistic experiences more personalized.

Recommendation systems in art personalization

Recommender systems have become a cornerstone of content personalization, revolutionizing the way users interact with content in the digital age. The latest trends are the use of recommender systems to personalize the art experience. Such systems use advanced algorithms and data analytics to curate art collections according to individual tastes, thereby increasing user engagement and satisfaction [5]. At the heart of this transformation is the ability of recommender systems to analyze vast amounts of data, including user interactions, preferences and reviews, to predict which artworks a user might like.

In the field of art personalization, recommender systems use different techniques such as collaborative filtering, content-based filtering, and hybrid models to offer personalized art experiences. Collaborative filtering analyzes patterns of past user behavior to recommend artworks that similar users like, while content-based filtering recommends art based on the characteristics of artworks the user has expressed interest in. Hybrid models combine both approaches, refining recommendations to provide a more nuanced and personalized art discovery experience [6, 7].

The authors of the publication «Hybrid Recommendations and Dynamic Authoring for AR Knowledge Capture and Re-Use in Diagnosis Applications» [8] explore the potential of hybrid recommendation systems

and dynamic authoring in the context of augmented reality for knowledge capture and its reuse in diagnostic applications. They point to the expansion of the capabilities of recommender systems beyond their traditional uses, emphasizing integration with complex technological solutions to improve diagnostic applications.

The impact of recommender systems on art personalization goes beyond simple convenience. This not only broadens the audience for artists and galleries, but also fosters a deeper cultural appreciation among the public.

In addition, these systems offer artists and curators valuable insights into audience preferences, guiding them to create and curate art that resonates more deeply with audiences. As recommendation technologies continue to evolve, their integration into art platforms promises to further enrich the landscape of art consumption, making art more accessible, engaging and personal than ever before.

NCF and GMF for processing user feedbacks

The use of neural collaborative filtering (NCF) and generalized matrix factorization (GMF) to process user feedback is becoming a best practice in the field of personalized recommendations. NCF, which uses deep neural networks to model interactions between users and objects, enables the detection of complex nonlinear dependencies in interaction data. This greatly improves the accuracy of recommendations, as NCF is able to gain a deeper understanding of users' subtle preferences and interests that may not be apparent using traditional methods [9].

On the other hand, GMF extends the classical factorization matrix approach by integrating it with neural networks to improve big data processing and discover hidden interaction factors. GMF uses a linear combination of latent characteristics of users and objects, offering a more accurate representation of their relationships. This allows recommender systems to not only more accurately predict potential user interest, but also take into account a wider range of user behaviors and feedback, ensuring high relevance of recommended content.

As the study conducted in the work «Study of methods for building recommendation system to solve the problem of selecting the most relevant video when creating virtual art compositions» [10] showed, the most effective approach to solving the problem of building a recommendation system of virtual art compositions is the approach hybridization, which consists in the combination within one model of different methods of building recommender systems, namely, the collaborative filtering method, the content-based method, and the knowledge-based method. The hybrid model, which combines all three methods, showed better results compared to models that implement each method separately. This is due to the fact that an additional deep neural network added to the hybrid of matrix factorization and collaborative filtering methods takes into account user characteristics when determining the video rating in the virtual art composition.

So, by combining NCF and GMF, a strong recommender system can be built that efficiently processes user feedback, providing personalized suggestions that take into account both explicit and implicit user preferences. This helps create a deeper and more engaging user experience, increasing user satisfaction and loyalty to the service. Therefore, the integration of NCF and GMF opens new horizons for the development of personalized services that can adapt to unpredictable changes in user preferences and behavior.

Using VSA to increase personalization

Let's analyze the latest publications related to VSA. Some current research focuses on sentiment analysis in YouTube comments. For example, in the article «Sentiment Analysis on Online Videos by Time-Sync Comments. Entropy» [11] authors use the methods of sentiment analysis and topic clustering to study educational content on YouTube. In particular, the authors consider how these techniques can be used to analyze comments to determine popular themes, emotional connection to material, and the overall effectiveness of educational content. The article presents different approaches to sentiment analysis, such as machine learning and deep learning, and their application to identify positive, negative, or neutral emotions in the textual content of comments.

Authors of publication «Learning Analytics on YouTube Educational Videos: Exploring Sentiment Analysis Methods and Topic Clustering» [12] describes the use of sentiment analysis for time-synchronized comments on videos. The authors focus on identifying and analyzing the emotional reactions of viewers at specific moments of the video, which allows for a dynamic understanding of content perception. The research findings show that this approach can be used to improve engagement and optimize video content, and provide clues for video content editors about how video affects the emotional state of viewers.

Using Video Sentiment Analysis (VSA) to improve personalization is an advanced approach that uses artificial intelligence to decode human emotions from video content. This innovative method opens up new ways to tailor user experience, content recommendations, and interactive services by understanding and responding to users' emotional states. VSA technology processes the video input by identifying facial expressions, body language and voice tones to determine the viewer's feelings in real time. This analysis provides a deep understanding of how content affects emotions, which can be used to personalize experiences in ways that resonate more deeply with each individual [13, 14].

Thus, the article «A Closer Look at Spatiotemporal Convolutions for Action Recognition» considers the possibility of using 3D CNN for multimodal spatiotemporal motion recognition [15]. This model can be adapted and used for VSA. In this way, it will be possible to achieve immediate user feedback for a recommender system working with interactive art.

Using recommender systems together with VSA to personalize interactive art opens up exciting prospects for creating unique art experiences. This combination allows not only to tailor artwork to the user's individual preferences based on their previous interactions, but also

to respond to their emotional state in real time, taking into account feedback from emotion analysis. This approach not only increases the individualization of the art consumption experience, but also creates a deeper emotional connection between the user and the art object, making interaction with art more meaningful and immersive.

Conclusion

The use of recommender systems based on processing implicit user feedback and video sentiment analysis in interactive art in AR opens up new perspectives for personalization of visual content. This approach allows not only to increase the satisfaction of users from works of art, but also to deepen the emotional connection between the work and the consumer. The introduction of these technologies has the potential to radically transform the way the user interacts with modern interactive art, making each experience unique and unique.

It is advisable to conduct further research with the inclusion of the generation of new interactive art content for each user, leveling or limiting the number of manually created virtual art compositions.

REFERENCES

1. Gironacci, Irene. (2021). State of the Art of Extended Reality Tools and Applications in Business. 10.4018/978-1-7998-4339-9.ch008.
2. Chen, Rongfei & Zhou, Wenju & li, yang & Zhou, Huiyu. (2022). Video-Based Cross-Modal Auxiliary Network for Multimodal Sentiment Analysis. IEEE Transactions on Circuits and Systems for Video Technology. PP. 1-1. 10.1109/TCSVT.2022.3197420
3. Wang, Fei. (2023). Research on the application of immersive art in digital technology scene. Advances in Education, Humanities and Social Science Research. 5. 88. 10.56028/aehssr.5.1.88.2023.
4. Zhang, Ying. (2023). Immersive Multimedia Art Design Based on Deep Learning Intelligent VR Technology. Wireless Communications and Mobile Computing. 2023. 1-8. 10.1155/2023/9266522.
5. Li, Huihong. (2023). Personalized Art Work Recommendation System and Methods Based on User Interest Characteristics and Emotional Preferences. Scalable Computing: Practice and Experience. 24. 883-894. 10.12694/scpe.v24i4.2393.
6. Patel, Dhruval & Patel, Foram & Chauhan, Uttam. (2023). Recommendation Systems: Types, Applications, and Challenges. 2210-142. 10.12785/ijcds/130168.
7. Duraisamy, Premkumar & Natarajan, Yuvaraj & .S, Yuvaraj & V.Niranjani,. (2023). An Overview of Different Types of Recommendations Systems - A Survey. 10.1109/ICITIIT57246.2023.10068631.
8. Fernández del Amo Blanco, Iñigo & Erkoyuncu, John & Farsi, Maryam & Ariansyah, Dedy. (2021). Hybrid recommendations and dynamic authoring for AR knowledge capture and re-use in diagnosis applications. Knowledge-Based Systems. 239. 107954. 10.1016/j.knosys.2021.107954.
9. He, Xiangnan & Liao, Lizi & Zhang, Hanwang. (2017). Neural Collaborative Filtering. Proceedings of the 26th International Conference on World Wide Web.
10. Kuliahin, Andrii & Narozhnyi, V. & Tkachov, V. & Kuchuk, H.. (2022). ДОСЛІДЖЕННЯ МЕТОДІВ ПОБУДОВИ РЕКОМЕНДАЦІЙНИХ СИСТЕМ ДЛЯ РОЗВ'ЯЗАННЯ ЗАДАЧІ ВИБОРУ НАЙБІЛЬШ РЕЛЕВАНТНОГО ВІДЕО ПРИ СТВОРЕННІ ВІРТУАЛЬНИХ АРТ-КОМПОЗИЦІЙ. Системи управління, навігації та зв'язку. Збірник наукових праць. 4. 94-99. 10.26906/SUNZ.2022.4.094.
11. Li, Jiangfeng & Li, Ziyu & Ma, Xiaofeng & Zhao, Qinpei & Zhang, Chenxi & Yu, Gang. (2023). Sentiment Analysis on Online Videos by Time-Sync Comments. Entropy. 25. 1016. 10.3390/e25071016.
12. Chalkias, Ilias & Tzafilkou, Katerina & Karapiperis, Dimitrios & Tjortjis, Christos. (2023). Learning Analytics on YouTube Educational Videos: Exploring Sentiment Analysis Methods and Topic Clustering. Electronics. 12. 3949. 10.3390/electronics12183949.
13. Li, Jiangfeng & Li, Ziyu & Ma, Xiaofeng & Zhao, Qinpei & Zhang, Chenxi & Yu, Gang. (2023). Sentiment Analysis on Online Videos by Time-Sync Comments. Entropy. 25. 1016. 10.3390/e25071016.
14. Deshmukh, Rushali & Amati, Vaishnavi & Bhamare, Anagha & Jadhav, Aditya. (2023). Visual Sentiment Analysis: An Analysis of Emotions in Video and Audio. 10.1007/978-981-99-6586-1_21.
15. Tran, Du & Wang, Heng & Torresani, Lorenzo & Ray, Jamie & LeCun, Yann & Paluri, Manohar. (2017). A Closer Look at Spatiotemporal Convolutions for Action Recognition.

Received (Надійшла) 24.11.2023
Accepted for publication (Прийнята до друку) 07.02.2024

Персоналізація візуального контенту інтерактивного мистецтва в доповненій реальності на основі індивідуальних уподобань користувачів

А. І. Кулягін

Анотація. Актуальність. У зв'язку з розвитком технологій AR та їх використанням у інтерактивному мистецтві, зростає потреба в розробці методів персоналізації візуального контенту, орієнтованих на індивідуальні вподобання користувачів. **Методи дослідження.** Метод нейронної колаборативної фільтрації, метод узагальненої матричної факторизації, аналіз настрою на відео. **Мета статті:** Дослідження можливостей покращення персоналізації візуального контенту в інтерактивному мистецтві через оцінку емоційних реакцій користувачів та їх неявних відгуків. **Отримані результати.** Було розглянуто застосування нейронної колаборативної фільтрації та узагальненої матричної факторизації для створення адаптованого візуального контенту в інтерактивному мистецтві в AR, що дозволить значно підвищити релевантність та зануреність користувачів в інтерактивні твори. **Висновок.** Розглянутий підхід може бути використаний для покращення імерсивності та персоналізації під час взаємодії користувача з інтерактивним мистецтвом в AR.

Ключові слова: інтерактивне мистецтво, доповнена реальність, нейронна колаборативна фільтрація, узагальнена матрична факторизація.