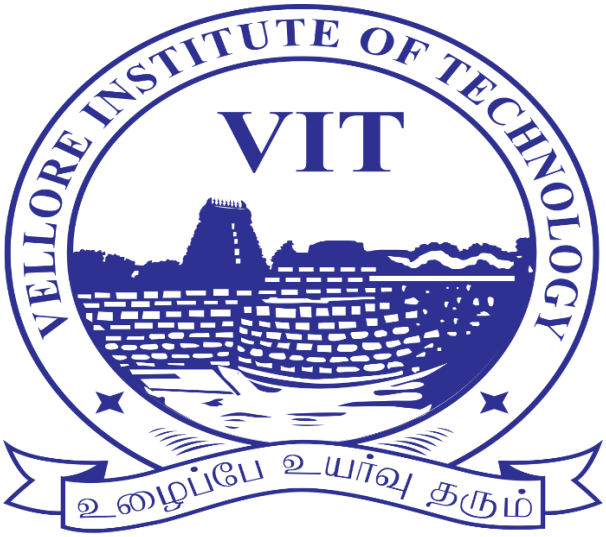

Big Data Frameworks

Review 1

Topic: Movie Recommendation System Using Reinforcement Learning

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Introduction

The rapid growth of digital platforms and the abundance of online content have made movie recommendation systems increasingly essential. These systems play a crucial role in helping users discover relevant movies based on their preferences, improving user engagement and satisfaction. Traditional movie recommendation systems have relied on collaborative filtering, content-based filtering, or hybrid approaches. However, in recent years, reinforcement learning (RL) has emerged as a promising technique for building more personalized and effective recommendation systems.

Reinforcement learning is a branch of machine learning that focuses on decision-making and sequential interactions. It revolves around an agent that learns to make optimal decisions through trial and error, guided by feedback from the environment. In the context of movie recommendation, the user's movie-watching behaviour becomes the environment, and the agent aims to learn the best movie suggestions to maximize user satisfaction.

Objectives

The specific objectives include:

- **Maximizing User Satisfaction:** The primary goal is to recommend movies that align with the user's preferences, leading to higher user satisfaction. By learning from user feedback and continuously adapting its recommendations, the system aims to improve the relevance and quality of movie suggestions over time.
- **Enhancing Personalization:** The system strives to provide personalized movie recommendations tailored to each user's individual tastes and preferences. By analyzing user behaviour, historical data, and contextual information, it aims to understand the user's preferences and make suggestions that align with their unique interests.
- **Handling Long-Term User Engagement:** The system aims to keep users engaged by providing a diverse range of movie recommendations that cater to different genres, actors, directors, or other relevant factors. It balances between exploring new recommendations to discover new user preferences and exploiting existing knowledge to provide recommendations that are likely to be well-received.
- **Adapting to Changing User Preferences:** User preferences may evolve over time, and the system should be able to adapt accordingly. By continuously learning from user interactions and updating its recommendation policies, the system can accommodate changing preferences and deliver up-to-date suggestions that reflect the user's current tastes.
- **Balancing Exploration and Exploitation:** The system needs to strike a balance between exploring new movie recommendations to learn more about user preferences and exploiting existing knowledge to provide accurate suggestions. It aims to avoid getting stuck in local optima by actively exploring different recommendations while also exploiting its learned knowledge to improve the recommendation quality.
- **Maximizing Cumulative Reward:** The reinforcement learning-based movie recommendation system aims to maximize the cumulative reward over time. The reward signal, typically based on user feedback or ratings, guides the learning process, encouraging the system to recommend movies that are likely to receive positive feedback and improve the overall user experience.

Literature Review

1. G. Pang, X. Zhu, K. Lu, Z. Peng and W. Deng, "**A simulator for reinforcement learning training in the recommendation field**," 2020 IEEE Intl Conf on Parallel & Distributed Processing with Applications, Big Data & Cloud Computing, Sustainable Computing & Communications, Social Computing & Networking (ISPA/BDCloud/SocialCom/SustainCom), Exeter, United Kingdom, 2020, pp. 1037-1042, doi: 10.1109/ISPA-BDCloud-SocialCom-SustainCom51426.2020.00156.

   Abstract: Deep reinforcement learning (DRL) is an unsupervised learning method, which has great commercial value in recommendation scenarios where it is difficult to collect available labelled data. Although very few researchers have begun to do research on the integration of deep reinforcement learning and recommendation methods, the development of these researches is slow because it is difficult to build an online training environment. Therefore, this paper proposes an environment (i.e. user) simulator for training reinforcement learning models in the recommendation field (RL-E Simulator). On the one hand, the simulator builds a user state generation model based on the Generative Adversarial Network (GAN). On the other hand, we propose an rating model based on attention mechanism, and realizes the reward of the simulator to the actions of DRL-based recommendation (i.e. agent). Experimental results show that the simulator provides a low-cost training environment for the DRL-based recommendation.
   URL: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9443735&isnumber=9443670

2. M. Pham, H. Nguyen, L. Dang and J. A. Nieves, "**Compressive Features in Offline Reinforcement Learning for Recommender Systems**," 2021 IEEE International Conference on Big Data (Big Data), Orlando, FL, USA, 2021, pp. 5719-5726, doi: 10.1109/BigData52589.2021.9671419.

   Abstract: In this paper, we develop a recommender system for a game that suggests potential items to players based on their interactive behaviours to maximize revenue for the game provider. Most of today's recommender systems in e-commerce and retail businesses are built based on supervised learning models and collaborative filtering, while our approach is built on a reinforcement-learning-based technique and is trained on an offline data set that is publicly available on an IEEE Big Data Cup challenge. The limitation of the offline data set and the curse of high dimensionality pose significant obstacles to solving this problem. Our proposed method focuses on improving the total rewards and performance by tackling these main difficulties. More specifically, we utilized sparse PCA to extract important features of user behaviors. Our Q-learning-based system is then trained from the processed offline data set. To exploit all possible information from the provided data set, we cluster user features to

different groups and build an independent Q-table for each group. Furthermore, to tackle the challenge of unknown formula for evaluation metrics, we design a metric to self-evaluate our system's performance based on the potential value the game provider might achieve and a small collection of actual evaluation metrics that we obtain from the live scoring environment. Our experiments show that our proposed metric is consistent with the results published by the challenge organizers. We have implemented the proposed training pipeline, and the results show that our method outperforms current state-of-the-art methods in terms of both total rewards and training speed. By addressing the main challenges and leveraging the state-of-the-art techniques, we have achieved the best public leader board result in the challenge. Furthermore, our proposed method achieved an estimated score of approximately 20% better and can be trained faster by 30 times than the best of the current state-of-the-art methods.
URL: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9671419&isnumber=9671273

3. X. He, K. Wang, H. Lu, W. Xu and S. Guo, "**Edge QoE: Intelligent Big Data Caching via Deep Reinforcement Learning,**" in IEEE Network, vol. 34, no. 4, pp. 8-13, July/August 2020, Doi: 10.1109/MNET.011.1900393.

Abstract: In mobile edge networks (MENs), big data caching services are expected to provide mobile users with better quality of experience (QoE) than normal scenarios. However, the increasing types of sensors and devices are producing an explosion of big data. Extracting valuable contents for caching is becoming a vital issue for the satisfaction of QoE. Therefore, it is urgent to propose some rational strategies to improve QoE, which is the major challenge for content-centric caching. This article introduces a novel big data architecture consisting of data management units for content extraction and caching decision, improving quality of service and ensuring QoE. Then a caching strategy is proposed to improve QoE, including three parts: (1) the caching location decision, which means the method of deploying caching nodes to make them closer to users; (2) caching capacity assessment, which aims to seek suitable contents to match the capacity of caching nodes; and (3) caching priority choice, which leads to contents being cached according to their priority to meet user demands. With this architecture and strategy, we particularly use a caching algorithm based on deep reinforcement learning to achieve lower cost for intelligent caching. Experimental results indicate that our schemes achieve higher QoE than existing algorithms.
URL: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9146409&isnumber=9146400

4. N. Yambem and A. N. Nandakumar, "**Optimizing Hadoop parameter for speedup using Q-Learning Reinforcement Learning**," 2021 Fourth International Conference on

Electrical, Computer and Communication Technologies (ICECCT), Erode, India, 2021, pp. 1-7, Doi: 10.1109/ICECCT52121.2021.9616965.

Abstract: Hadoop is the most popular open-source big data processing platform which is being used in many big data analytics applications. The performance of Hadoop can be fine-tuned for application performance requirements by adjusting the value of the some of the configuration parameters. Various methods have been proposed in literature for fine tuning the configuration parameters of Hadoop. The relation between the Hadoop performance tuning parameters and speed up is dependent on the nature of the applications and environment dynamics. Tuning the parameters without consideration of these dynamics results in sub optimal configurations and lower performance. Adaptive reinforcement learning using Q-Learning is proposed in this work to fine tune the configuration parameters with the objective of reducing the error between desired and achieved service level agreement (SLA).
URL: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9616965&isnumber=9616621

5. M. Tracolli, M. Baioletti, V. Poggioni and D. Spiga, "**Effective Big Data Caching through Reinforcement Learning**," 2020 19th IEEE International Conference on Machine Learning and Applications (ICMLA), Miami, FL, USA, 2020, pp. 1499-1504, Doi: 10.1109/ICMLA51294.2020.00231.

Abstract: In the era of big data, data volumes continue to grow in several different domains, from business to scientific fields. Sensors, edge devices, scientific applications and detectors generate huge amounts of data that are distributed for their nature. In order to extract value from such data requires a typical pipeline made of two main steps: first, the processing and then the data access. One of the main features for data access is fast response time, whose order of magnitude can vary a lot depending on the specific type of processing as well as processing patterns. The optimization of the access layer becomes more and more important while dealing with a geographically distributed environment where data must be retrieved from remote servers of a data lake. From the infrastructural perspectives, caching systems are used to mitigate latency and to serve better popular data. Thus, the role of the cache becomes a key to have an effective and efficient data access. In this article, we propose a Reinforcement Learning approach, using the Q-Learning technique, to improve the performances of a cache system in terms of data management. The proposed method uses two agents with different objectives and actions to control the addition and the eviction of files in the cache. The aim of this system is to increase the throughput reducing, at the same time, the cache costs, such as the amount of data written, and network utilization. Moreover, we tested our method in a context of data analysis, with information taken from High Energy Physics (HEP) workflow.
URL: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9356236&isnumber=9356131

6. S. Bangari, S. Nayak, L. Patel and K. T. Rashmi, "**A Review on Reinforcement Learning based News Recommendation Systems and its challenges**," 2021 International Conference on Artificial Intelligence and Smart Systems (ICAIS), Coimbatore, India, 2021, pp. 260-265, Doi: 10.1109/ICAIS50930.2021.9395812.

Abstract: Recommendation systems are helpful in both business perspective and user day to day life. These days online contents are generated in huge amount and due to this, users need a special recommendation application namely personalized News Recommendation, and it is highly challenging due to its dynamic nature. Therefore, getting a suitable and relevant news article for a user is difficult task. To address the above challenge Reinforcement Learning algorithms plays crucial role because these algorithms very much helpful in dealing with the dynamic environment and large space. This paper reviews the different Reinforcement algorithms namely Deep Q-learning network (DQN), Deep Deterministic Policy Gradient (DDPG) and Twin Delayed DDPG (TD3) to develop the news recommendation system and also mentioned the challenges faced by the reinforcement recommendation systems. In this study it was found that TD3 is best suited to develop the news recommendation system.
URL: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9395812&isnumber=9395748

7. X. Gao and M. Qiu, "**Recommendation System Design for Social Media using Reinforcement Learning**," 2022 IEEE 9th International Conference on Cyber Security and Cloud Computing (CSCloud)/2022 IEEE 8th International Conference on Edge Computing and Scalable Cloud (EdgeCom), Xi'an, China, 2022, pp. 6-11, doi: 10.1109/CSCloud-EdgeCom54986.2022.00011.

Abstract: Recommendation System plays an important role in capturing consumers' preference. In order to better utilize the effectiveness of the recommendation system, many social media platforms have developed algorithms to improve their performance. However, there are still a lot of platforms that keep recommending the same but useless contents to the customers, which even reduce the customers' interest in using these social media platforms. In response to this problem, we propose to transplant reinforcement learning to build efficient and effective recommendation system. Specifically, we decide to update our recommendation system frequently by taking all customers' behaviors into consideration to improve accuracy of the system's recommendation output. The experiment results show that our system can gain more than 100% profits and can converge to the optimal result quickly.
URL: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9842879&isnumber=9842867

8. K. S and G. K. Shyam, "**Review of Deep Reinforcement Learning-Based Recommender Systems**," 2022 Third International Conference on Smart Technologies in Computing,

Electrical and Electronics (ICSTCEE), Bengaluru, India, 2022, pp. 1-12, doi: 10.1109/ICSTCEE56972.2022.10099739.

Abstract: Recommender systems (RS) are an indispensable technology that helps to address the issue of information explosion in the digital age. It can assist the customers by proposing personalized items and providers by increasing traffic to their website. Recommender systems can be applied to variety of business use cases including but not limited to electronic commerce applications and media recommendation (e.g., news, motion pictures, music, and videos). Deep reinforcement learning (DRL)-based RS has recently gained popularity as a research topic. Because of its interactive approach and autonomous learning ability, it frequently outperforms classic recommendation approaches, including deep learning-based methods. The objective of this work is to present a thorough overview of the state of the art for DRL implementations in recommendation systems. This paper starts with the background technologies involved in applying DRL in RS. Then, this paper examines recent advancements in DRL-based RS and discusses open issues. This review serves as an introduction to the topic of DRL in RS and its various facets. It identifies potential areas of research and provides valuable feedback to readers from academic and industry.
URL: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=10099739&isnumber=10099487

9. Z. Yuyan, S. Xiayao and L. Yong, "**A Novel Movie Recommendation System Based on Deep Reinforcement Learning with Prioritized Experience Replay**," 2019 IEEE 19th International Conference on Communication Technology (ICCT), Xi'an, China, 2019, pp. 1496-1500, doi: 10.1109/ICCT46805.2019.8947012.

   Abstract: A recommendation system plays an important role in information overload case by recommending personalized services to improve user experience. In this paper, a novel movie recommendation system based on deep reinforcement learning (DRL) framework is proposed. In proposed system model, the state information is preprocessed to overcome the problems of data sparsity and cold start. Specially, user's interest change is captured using cross entropy and used to prioritize experience replay in a replay memory. The experiments verify that the proposed model can speed up the network update and improve recommendation accuracy.
   URL: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8947012&isnumber=8946993

10. N. Guo, Z. Fu and Q. Zhao, "**Multimodal News Recommendation Based on Deep Reinforcement Learning**," 2022 7th International Conference on Intelligent Computing and Signal Processing (ICSP), Xi'an, China, 2022, pp. 279-284, Doi: 10.1109/ICSP54964.2022.9778361.

Abstract: Multimodal news recommendation is a challenging problem due to the rapid expansion of Internet information, bringing different levels of knowledge expression such as text, images, audio, and video, etc. In this paper, we propose a multimodal news recommendation method based on a deep reinforcement learning framework to represent user interests as multimodal information. The proposed method feeds the multimodal fusion feature into the rainbow agent of deep reinforcement learning to learn news representation. The experiment on the MIND and IM-MIND datasets gives the result of AUC, MRR, nDCG@5, and nDCG@10 scores, which outperform LSTUR, FIM, and DKN, NRMS, NPA, and DeepFM models. It shows that reinforcement learning is an excellent choice to fulfill recommendation tasks, and the multimodal fusion feature is effective for learning accurate news representations.
URL: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9778361&isnumber=9778231