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| Host Organisation | Norwegian University of Science and Technology(NTNU) |
| Scientific coordinator | Christopher Frantz |



I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

During my ERCIM research programme, I focus on how to mine user behavior preferences more accurately from real-world data and the application of artificial intelligence technology in recommender systems and other fields.

In the early stage of the programme, I mainly learned about the construction of knowledge graphs and the Institutional Grammar 2.0 A specification for encoding and analyzing institutional proposed by Professor Christopher Frantz. And I learned the use of Neo4j, a software for building knowledge graphs. Based on the above efforts, I learned how to use real-world user behavior data to build a knowledge graph.

In the middle of the programme, based on my research foundation in the early stage of the programme, my research focuses on the application of machine learning, especially deep learning in the field of recommendation systems. To address the essential difference between the user and the item reviews, my collaborators and I propose a novel Asymmetric Multi-Level Interactive Attention Network (AMLIAN) integrating reviews for item recommendation. In order to use the high-order neighbourhood information in user check-in trajectories and their social relationships to improve the performance of point-of-interest recommendation, I propose a Double-Layer Attention Network recommendation model. I also improved on a next POI recommendation method that integrates geospatial and temporal preferences that I proposed earlier. At this stage, I communicated with researchers at CWI to learn about their research status on recommendation systems.

At the end of the programme, my research focus shifted to how to better apply artificial intelligence to the field of renewable energy. And I communicated and discussed with researchers from the University of Navarra.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

During my fellowship, I have completed three journal papers, one of which has been accepted and the other two are still under review.

Paper 1-Accepted (publishing):

Title: *Asymmetric multilevel interactive attention network integrating reviews for item recommendation*

Authors: *Peilin Yang, Wenguang Zheng, Yingyuan Xiao and Xu Jiao*

References: *Intelligent Data Analysis*

Abstract: *Recently, most studies in the field have focused on integrating reviews behind ratings to improve recommendation performance. However, two main problems remain (1) Most works use a unified data form and the same processing method to address the user and the item reviews, regardless of their essential differences. (2) Most works only adopt simple concatenation operation when constructing user-item interaction, thus ignoring the multilevel relationship between the user and the item, which may lead to suboptimal recommendation performance. In this paper, we propose a novel Asymmetric Multi-Level Interactive Attention Network (AMLIAN) integrating reviews for item recommendation. Specifically, to address the essential difference between the user and the item reviews, AMLIAN uses the asymmetric network to construct user and item features*



using different data forms (document-level and review-level). To learn more personalized user-item interaction, the user ID and item ID and some processed features of user reviews and item reviews are respectively used for multilevel relationships. Experiments on five real-world datasets show that AMLIAN significantly outperforms state-of-the-art methods.

Paper 2-Pending (under review, submitted to Journal of Intelligent & Fuzzy Systems):

Title: DLAN: Modeling user long- and short-term preferences based on double-layer attention network for next point-of-interest recommendation

Authors: Yuhang Wu, Xu Jiao, Qingbo Hao, Yingyuan Xiao and Wenguang Zheng

References: submitted to Journal of Intelligent & Fuzzy Systems

Abstract: The next Point-of-Interest(POI) recommendation, in recent years, has attracted an extensive amount of attention from the academic community. RNN-based methods cannot establish effective long-term dependencies among the input sequences when capturing the user's motion patterns, resulting in an inadequate exploitation of user preferences. Besides, the majority of prior studies often neglect high-order neighbourhood information in users' check-in trajectory and their social relationship, yielding suboptimal recommendation efficacy. To address these issues, this paper proposes a novel Double-Layer Attention Network model, named as DLAN. Firstly, DLAN incorporates a multi-head attention module that can combine first-order and high-order neighbourhood information in user check-in trajectories, thereby effectively and parallelly capturing both long- and short-term preferences of users and overcoming the problem that RNN-based methods cannot establish long-term dependencies between sequences. Secondly, this paper designs a user similarity weighting layer to measure the influence of other users on the target users in order to leverage the social relationships among them. Finally, comprehensive experiments are conducted on user check-in data from two cities, New York (NYC) and Tokyo (TKY), and the results demonstrate that DLAN achieves a performance enhancement of 8.07%-36.67% compared to the state-of-the-art method.

Paper 3-Pending (under review, submitted to Journal of Heliyon):

Title: IGTP: A Next Point-of-Interest Recommendation Method that Integrates Geospatial and Temporal Preferences

Authors: Xu Jiao, Yingyuan Xiao, Xuesong Su, Wenguang Zheng and Ke Zhu

References: submitted to Journal of Heliyon

Abstract: With the rapid development of location-based social networks(LBSNs), point-of-interest(POI) recommendation has become an important way to meet the personalized needs of users. The purpose of POI recommendation is to provide personalized POI recommendation services for users. However, general POI recommendations cannot meet the individual needs of users. This is mainly because the decision-making process for users to choose POIs is very complicated and will be affected by various user contexts such as time, location, etc. This paper proposes a next POI recommendation method that integrates geospatial and temporal preferences, called IGTP. Compared with general POI recommendation, IGTP can provide more personalized recommendations for users according to their contextual information. First, IGTP uses users' preferences information to model users' check-in histories to effectively overcome the challenge of extremely sparse check-in data. Secondly, IGTP takes into account the geographic distance and geographic density that affect people's choice of POIs, and limits POIs to be recommended to the potential activity area centered on the current location of the target user. Finally, IGTP integrates geospatial and users' temporal preferences information into a unified recommendation process.



Compared with six advanced baseline methods, the experimental results demonstrate that IGTP achieves much better performance.

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

In my research program, the research groups I am involved in have one or two seminars per week, I have attended many, I will just list a few.

Seminars:

- (1) Title: *Institutional Grammar 2.0 A specification for encoding and analyzing institutional*
Date: August 19th, 2022
Place: NTNU Gjøvik
Name: Christopher Frantz (associate professor)
- (2) Title: *User Behavior Analysis and Knowledge Graph Construction*
Date: December 6th, 2022
Place: online
Name: Yingyuan Xiao (professor)
- (3) Title: *Application of Deep Learning in User Behavior Analysis*
Date: March 21th, 2023
Place: online
Name: Wenguang Zheng (associate professor)
- (4) Title: *Application of artificial intelligence in the field of renewable energy*
Date: May 23th, 2023
Place: online
Name: Yuemin Ding (associate professor)
- (5) Title: *MSCA Postdoctoral Fellowships - Proposal drafting tips*
Date: June 9th, 2023
Place: online
Name: MSCA NCP Team
- (6) Title: *Discuss current research work and exchange ideas on future collaborations*
Organisation: University of Navarra
Country: Spain
Department or project: Tecnun School of Engineering
Local scientific coordinator: Yuemin Ding
Dates: 31th May, 2023 to 3rd June, 2023

IV – RESEARCH EXCHANGE PROGRAMME (REP)

During my research programme, I have finished a REP.

Organisation: CWI
Country: the Netherlands
Department or project: Intelligent and Autonomous Systems
Local scientific coordinator: Eric Pauwels
Dates: 30th April, 2023 to 6th May, 2023
During the REP, we discussed research work and exchanged ideas for future collaborations.