# Formal Project Proposal template

Due 27 March 2025

|  |  |
| --- | --- |
| **Name:** | ROHIT NAYAK |
| **Programme:** | MSC Information Technology |
| **Student ID:** | 24061345 |
| **Project Title:** | *Consumer Behavior Prediction in E-Commerce Using Graph Neural Networks (GNNs)* |
| **Problem you are seeking to address:** | *Unlike physical goods stores, which are easy to forecast consumer behavior, e-commerce sites, due to the complexity of customer-product interactions, is very difficult. The traditional recommendation models collaborative filtering and content based filtering have limited capabilities to capture the dynamic purchasing behavior and hence it gives the generic recommendation and poor customer engagement. Moreover, the models do not take into account repeat purchases, co-occurrence of products, and seasonal trends, all of which are fundamental to perform targeted marketing, as well as to provide need forecasts.*  *The encoding of the customer product interactions on a graph model using Graph Neural Networks (GNNs) show promises as they enable learning of latent patterns and behavioral tendencies of customers. The e-commerce dataset will be used for modelling repeat customer behavior, interdependencies between purchases, and time based trends using GNNs. Such critical ethical topics of data privacy and model fairness are considered by the proposed methodology to strengthen recommendation accuracy, customer segmentation and seasonal demand prediction. Then, a very fine comparison will be performed on the GNN based predictions to traditional procedures.* |
| **Aim and scope:** | ***Aim***  *The focus of this study is to construct a Graph Neural Networks (GNN) based model for predicting the consumer behavior in the e-commerce. The study attempts to increase the accuracy of predicting repeat purchase, segmenting the customers based on customer behavior and forecast variations in seasonal demand, all with the help of transactional data. These traditional recommendation systems, including collaborative filtering, cannot model complicated dependencies of the purchase and dynamic consumers’ preferences (Wu et al., 2022). However, the GNNs approach to customer-product interactions as a graph and allows the capture of hidden patterns in consumer behavior (Gao et al., 2023).*  ***Scope***  *This study aims to develop a graph of consumer transactions and a customer product interaction to understand the consumer transactions. Purchase history, product co-occurrence, temporal trends, all are necessary to predict customer behavior in the data. Then, using the research, it will be explored as to how GNNs improve over traditional methods in recommendation accuracy and personalization (Delianidi et al., 2022). Additionally, the research will examine seasonal purchasing pattern for demand forecasting optimization in which graph based models have shown promise (Li et al., 2024).*  *Data privacy and bias reduction ethical issues are addressed in an attempt to allow equitable and responsible AI adoption. Similarly, GNN based predictions are compared with conventional recommendation models within the testing phase to validate the merit of graph based consumer behavior modeling.* |
| **Project objectives:** | * *To develop a Graph Neural Network (GNN)-based model that predicts consumer buying behavior from customer-product interactions in an e-commerce dataset.* * *To identify repeat purchase behavior and segment customers based on transactional history to enable targeted recommendations and one-to-one marketing.* * *To study seasonal trends in purchasing behavior and improve demand forecasting by incorporating temporal features in the GNN model.* * *To compare the performance of the GNN-based model with traditional recommender methods, evaluate the effectiveness based on measures such as precision, recall, and F1-score.* |
| **Expected project outcomes:** | *To achieve this, a predictive model that analyzes consumer purchasing behavior in online shopping will be designed in the form of a Graph Neural Network (GNN) based approach. The model will be able to learn the repetitive patterns of purchases, customer product relationships and the seasonal trends, and will be able to make more accurate and personalised recommendations against other methods. The model would represent customer interaction as graph, and it will discover latent relationship between products and user interactions, hence the better recommendation accuracy and customer interest.*  *Moreover, the system will also allow segmentation of customers according to purchase frequency and customer preference that will help businesses create targeted marketing campaigns. Additionally, the model incorporates time association patterns and improves the demand forecasting which can apply towards inventory management and optimizing of promotional campaign.*  *The artefact will overcome current shortcomings of recommender systems, not being able to handle dynamic consumers behavior, and product interrelatedness, with the application of GNNs. After the evaluation phase, improvements in the recommendation accuracy and demand prediction will be compared with existing approaches to validate them.* |
| **Brief review of relevant literature:** | *As GNNs are able to model complex user item interaction relationships in recommending systems, they have become increasingly popular. Furthermore, as shown in Krishnamurthy et al. (2024), session and category aware recommendation can be achieved with GNN and this can be exploitation in customer preference modeling of e-commerce. Finally, Wu et al. (2022) and Gao et al. (2023) provide comprehensive surveys on the applications of GNNs in recommender systems where an overview of various methodologies and challenges as well as future directions are covered.*  *This project’s focus on repeat purchases complements the discussion of Delianidi et al. (2022) in how they describe graph based session modeling for e-commerce. To deal with seasonality, temporal augmented GNNs proposed by Zhou et al. (2021) can be used in session based recommendation. Supporting the seasonal analysis component of this study, Li et al. (2024) and Gandhi et al. (2021) do discuss demand forecasting using GNNs. Together, these references offer theoretical and empirical foundations to use GNN in predicting consumers’ behaviors.* |
| **[optional] References:** | 1. *Krishnamurthy, S., Piridi, H.P., Pervin, N., Thiruvenkadam, G. and Ghosh, R., Session and Category Aware Recommendation with Graph Neural Networks. Available at SSRN 4789174.* 2. *Wu, S., Sun, F., Zhang, W., Xie, X. and Cui, B., 2022. Graph neural networks in recommender systems: a survey. ACM Computing Surveys, 55(5), pp.1-37.* 3. *Gao, C., Zheng, Y., Li, N., Li, Y., Qin, Y., Piao, J., Quan, Y., Chang, J., Jin, D., He, X. and Li, Y., 2023. A survey of graph neural networks for recommender systems: Challenges, methods, and directions. ACM Transactions on Recommender Systems, 1(1), pp.1-51.* 4. *Delianidi, M., Diamantaras, K., Tektonidis, D. and Salampasis, M., 2022. Session-Based Recommendations for e-Commerce with Graph-Based Data Modeling. Applied Sciences, 13(1), p.394.* 5. *Wu, C., Liu, Z. and Li, Z., 2025. Identification of Malicious E-commerce Users Based on User Rating Behavior and GNN. Informatica, 49(10).* 6. *Xv, G., Lin, C., Guan, W., Gou, J., Li, X., Deng, H., Xu, J. and Zheng, B., 2023, August. E-commerce search via content collaborative graph neural network. In Proceedings of the 29th ACM SIGKDD conference on knowledge discovery and data mining (pp. 2885-2897).* 7. *Zhou, H., Tan, Q., Huang, X., Zhou, K. and Wang, X., 2021, July. Temporal augmented graph neural networks for session-based recommendations. In Proceedings of the 44th International ACM SIGIR conference on research and development in information retrieval (pp. 1798-1802).* 8. *Li, J., Fan, L., Wang, X., Sun, T. and Zhou, M., 2024. Product demand prediction with spatial graph neural networks. Applied Sciences, 14(16), p.6989.* 9. *Gandhi, A., Aakanksha, Kaveri, S. and Chaoji, V., 2021, September. Spatio-temporal multi-graph networks for demand forecasting in online marketplaces. In Joint European Conference on Machine Learning and Knowledge Discovery in Databases (pp. 187-203). Cham: Springer International Publishing.* 10. *Kozodoi, N., Zinovyeva, E., Valentin, S., Pereira, J. and Agundez, R., 2024. Probabilistic demand forecasting with graph neural networks. arXiv preprint arXiv:2401.13096.* |
| **Testing and Evaluation:** | *The GNN-based model performance will be quantitatively evaluated based on precision, recall, F1-score, and normalized discounted cumulative gain (NDCG) to compare the recommendation accuracy. The model will be compared to traditional recommendation methods, including collaborative filtering and deep learning-based models, in its ability to predict repeat purchases and seasonal demand patterns. Visualization techniques will be used to explore customer segmentation and product relationships within the graph structure. Time-series analysis will be conducted to estimate the model's ability in capturing seasonal purchasing behavior for demand forecasting improvement.* |
| **Ethical considerations:** | *The dataset includes customer transaction history, and data privacy is the utmost concern. Customer IDs will be anonymized for confidentiality, and ethical AI principles will be maintained to prevent biased recommendations. There is no primary data collection in the project; all the data to be utilized will be pre-existing e-commerce transaction history. Ethical considerations will be ongoing to achieve responsible AI standards.* |
| **Project plan:** |  |
| **Signature:** | *Sign your project plan at the end.* |

Excluding your project title and references, your proposal should be a maximum of 1000 words in length. If using this template, then it would be at most 3 pages excluding references.