Research Statement

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My research focuses on developing collaborative filtering recommender systems by leveraging machine learning and deep learning techniques. Specifically, I address key challenges such as the cold start and data sparsity problems by designing models that integrate both explicit and implicit user feedback. My work explores the use of deep neural networks to enhance traditional collaborative filtering approaches, aiming to improve recommendation accuracy, scalability, and adaptability to dynamic user preferences. This research combines expertise from recommender systems, machine learning, deep learning, and large-scale data processing to build more intelligent and robust recommendation frameworks.

Overview

My research primarily focuses on the development of collaborative filtering recommender systems, leveraging advanced machine learning and deep learning techniques to address key challenges in personalization and recommendation. One of the main challenges in recommender systems is the cold start problem, where limited user data impedes accurate recommendations. To tackle this, my work explores the integration of both explicit and implicit user feedback, enhancing recommendation accuracy through novel model designs.

A major aspect of my research is the application of deep learning approaches, including deep neural networks, to improve traditional collaborative filtering methods. By combining these techniques with large-scale data processing, my work aims to develop scalable and adaptable recommendation frameworks that can handle dynamic and evolving user preferences. These advancements are crucial in building more intelligent recommender systems capable of providing real-time, personalized experiences across various domains.

As a future direction, I plan to focus on the intersection of deep learning and reinforcement learning, particularly in addressing issues such as data sparsity and improving the efficiency of recommendation systems. Additionally, I aim to tackle the challenge of the "black box" nature of deep learning models in recommender systems, which often lack transparency in decision-making. My research will focus on developing explainable recommendation systems, where the reasoning behind a recommendation is made clear to users, improving trust and user satisfaction. I believe that explainability in recommender systems is crucial, especially in high-stakes applications like healthcare or finance, where users need to understand the rationale behind recommendations.

I am also interested in exploring how reinforcement learning can be used to adapt to changing user preferences, enabling systems to continuously improve based on real-time feedback. My ultimate goal is to create more robust, efficient, and scalable recommender systems that combine machine learning, human feedback, and explainability to provide optimal recommendations.

Past Research work

In my thesis work, I proposed a hybrid recommendation model, namely ΓUICF. The ΓUICF model integrates user-based CF (UCF) and item-based CF (ICF) models with Γ linear regression to model the sparsity and scalability issues of the user-item rating matrix. The different major similarity computations between users to users and items to items are computed, and then the prediction for the unobserved target rating is made by adapting UCF and ICF models in the offline step. The Γ parameter linear regression model learns for each user and item and fuses the two predictions in the online step into a weighted model. The experiments were conducted on two different real-world datasets, namely the 100k and 1M MovieLens datasets. Furthermore, a novel neural recommendation model is proposed based on non-independent and identically distributed (Non-IID) for CF by incorporating explicit and implicit coupling interactions. The explicit interactions consist of two models, namely Intra-coupling interactions within users and items, and Inter-coupling interactions between different users and items concerning the attributes of users and items. The Intra-coupled model learns using deep learning convolutional neural networks and is combined with the Inter-coupled model. Besides explicit coupling interactions, I presented a Generalized Matrix Factorization Bias (GMFB) model that systematically trains the implicit user-item coupling. Finally, I combined explicit and implicit coupling interactions within and between users and items, accompanying the extra information about users and items under a framework called "IntegrateCF." Additionally, I proposed a movie recommendation system based on Alternating Least Square (ALS) using Apache Spark. I foced on the selection of parameters of ALS algorithms that can affect the performance of a robust RS. From the results, a conclusion is drawn according to the selection of parameters of ALS algorithms, which can affect the performance of building of a movie recommendation engine. The model evaluation is done using different metrics such as execution time, root mean squared error (RMSE) of rating prediction, and the rank at which the best model was trained. Two best cases are chosen based on best parameter selection from experimental results, which can lead to building a good prediction rating for a movie recommender.

Finally, a novel a survey of the challenges, solutions, and conventional and newly emerged CF RS based on machine learning (ML) and deep learning (DL) algorithms. The survey provides insight and guides beginner and advanced researchers interested in the domain of RS. It is divided into two dimensions: one for beginners and one for advanced readers. The first dimension is devoted to explaining the basic concept of an RS, while the second dimension is devoted to explaining the remedies for RS issues, tasks of each paper, most metrics, and most datasets among all studies. In this survey, 320 systematic references were chosen based on things like how many recent citations the article had and the quality of the journal, international conference, or book chapter where the paper was published.

Current Research and Professional Activities

Currently, I serve as a co-supervisor for several Ph.D. students in the Department of Computer Science at Mangalore University, guiding research primarily in the fields of recommender systems

and sentiment analysis. Our research group has developed and enhanced multiple research projects, among which the most notable are:

- **Sentiment Analysis on Amazon Women's E-Commerce Clothing Reviews Dataset**: We conducted a comprehensive sentiment analysis using CountVectorizer and TF-IDF techniques, training the data on five machine learning (ML) classifiers: Logistic Regression (LR), Multinomial Naive Bayes (MNB), Bernoulli Naive Bayes (BNB), Support Vector Machine (SVM), Random Forest (RF), and AdaBoosting (AB).
- **Fine-tuning Transformer Models for Sentiment Analysis**: We performed a comparative evaluation of transformer-based models, specifically fine-tuning XLNet for sentiment analysis on Amazon reviews, highlighting the effectiveness of advanced deep learning models over traditional machine learning techniques.
- **Hyperparameter Optimization**: We explored the optimization of ML models through grid search techniques to improve the performance of sentiment analysis tasks on the Amazon review dataset.

In parallel with my academic research, I am actively engaged in developed projects within the Ministry of Agriculture. Key projects include:

- **Agricultural Projects Management System:** I led the development of a comprehensive management web-system for agricultural projects and units, covering all stages of project operations, from planning to execution and monitoring.
- **Diesel and Petrol Management System:** I developed and implemented a specialized web-system, including an Android application, to manage and monitor the distribution of diesel and petrol supplies allocated to agricultural projects across all provinces in the country. This system ensures transparency and efficient resource management within the Ministry of Agriculture.
- **Dairy Collection Management System:** I developed a web-system with Android applications to organize and streamline the collection and delivery of dairy products between collectors, factory representatives, and cooperative associations, enhancing coordination and traceability in the dairy supply chain.

Additionally, in my role as an Assistant Professor at the Department of Artificial Intelligence at Al-Razi University, I supervise numerous undergraduate graduation projects. Among the most significant projects are:

- **Digital Agriculture Project:** This project focuses on leveraging artificial intelligence and IoT technologies to improve agricultural productivity through real-time monitoring and smart decision support systems.
- **Contract Farming System:** A project aimed at digitizing the processes of contract farming agreements, connecting farmers directly with buyers through an intelligent platform that ensures transparency and fair-trade practices.

Through these academic and professional activities, I strive to bridge the gap between theoretical research and practical applications, contributing both to scientific advancement and real-world problem-solving.

Future Research

Looking ahead, I plan to extend my research in several advanced directions within artificial intelligence and recommender systems:

- **Explainable Recommender Systems (XRS):** Traditional recommendation algorithms often operate as black boxes, which limits transparency and user trust. I plan to design explainable recommendation models that provide interpretable justifications for their suggestions. My work will leverage knowledge graphs, attention-based deep learning, and post-hoc explainability techniques to enhance the transparency and trustworthiness of recommendations.
- **Fairness, Accountability, and Bias Mitigation in Recommender Systems:** Recognizing that algorithmic bias can significantly affect user experience and perpetuate inequalities, I intend to create fairness-aware recommender systems. My research will focus on developing mechanisms that detect, quantify, and mitigate biases while preserving model accuracy and personalization quality.
- **Graph-Based Recommendation and Knowledge Discovery:** Building on collaborative filtering and network analysis, I am interested in applying graph neural networks (GNNs) to uncover deeper user-item-context relationships. By modeling users and items as nodes in heterogeneous graphs, I aim to enable more accurate, context-aware, and scalable recommendations.
- **Human-Centered AI and Human-in-the-Loop Recommender Systems:** Inspired by principles of human computation, I plan to integrate dynamic human feedback within AI pipelines. This includes designing systems that adapt to noisy, sparse, or evolving user data through active learning, crowd-sourced annotations, and hybrid human-machine collaborative decision-making.
- **Federated Learning for Privacy-Preserving Recommender Systems and Sentiment Analysis:** With increasing concerns over data privacy and security, I aim to develop federated learning frameworks for training recommendation models and sentiment analysis systems without centralized data collection. This approach will enable collaborative model training across decentralized devices while maintaining user confidentiality, particularly for sensitive domains such as e-commerce and healthcare.

By pursuing these directions, my long-term goal is to contribute to building next-generation intelligent systems that are privacy-preserving, explainable, fair, and deeply aligned with human needs and values.

References

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