A HYBRID RECOMMENDATION MODEL USING MULTI-LEVEL SENTIMENT AND RATING INTERACTIONS

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ABSTRACT— To investigate the impact of cross-grained sentiments on user feature representation and address the issue of data sparsity, this paper proposes a Personalized Recommendation Algorithm Integrating Cross-Grained Sentiment and Rating Interaction Features (ICSR). The algorithm begins by employing a pre-trained BERT (Bidirectional Encoder Representations from Transformers) model and a Bi-GRU (Bidirectional Gated Recurrent Units) network to derive feature vectors from user and item reviews. Sentiment dictionaries and attention mechanisms are then applied to assign appropriate weights to the review features of users and items, respectively. To capture a richer set of sentiment features, a cross-grained sentiment feature fusion module is introduced. This module leverages an LDA (Latent Dirichlet Allocation) model and dependency syntactic analysis techniques to extract fine-grained sentiment features, while a word2vec pre-trained model and sentiment dictionaries are used to capture coarse-grained sentiment features. These features are then fused to form comprehensive cross-grained sentiment representations. Finally, rating interaction features are extracted using matrix factorization techniques, and all features are integrated and fed into a DeepFM model for rating prediction. Experimental results on Amazon datasets demonstrate that the proposed ICSR algorithm significantly outperforms baseline algorithms in terms of recommendation performance.

Index Terms – Personalized recommendation, BERT, Bidirectional Gated Recurrent Unit (Bi-GRU), DeepFM, cross-grained sentiment analysis, recommendation

systems, rating prediction, Latent Dirichlet Allocation (LDA), word2vec, matrix factorization, attention mechanism, sentiment analysis, user review mining.

I. INTRODUCTION

In recent years, the explosive growth of digital platforms such as Amazon, Netflix, and Facebook has led to an unprecedented surge in user-generated content, product information, and interaction data, intensifying the problem of information overload and making personalized recommendation systems an essential component of modern intelligent services. Traditional recommendation techniques, particularly collaborative filtering and content-based filtering, primarily rely on explicit rating data or simple behavioral interactions to infer user preferences; however, these approaches often suffer from data sparsity, cold-start issues, and limited interpretability, especially when users provide few ratings or when new items are introduced into the system. With the increasing availability of rich textual reviews accompanying ratings, researchers have recognized that user reviews contain nuanced sentiment signals and detailed opinions about various aspects of items, offering deeper insight into user preferences beyond numerical scores alone. Nevertheless, many existing sentiment-aware recommendation models focus on single-granularity sentiment analysis, either emphasizing coarse-grained overall sentiment polarity at the sentence or document level or concentrating solely on fine-grained aspect-level sentiment extraction, thereby failing to capture the complex and often contradictory emotional expressions embedded in natural language. In real-world scenarios, users frequently express mixed sentiments within a single review, praising certain attributes of a product while criticizing others, and such cross-grained emotional signals, if properly modeled, can significantly enhance user representation and recommendation accuracy. To address these limitations, this project proposes a Hybrid Recommendation Model Using Multi-Level Sentiment and Rating Interactions, also referred to as the ICSR framework, which integrates cross-granularity sentiment features with latent rating interaction features in a unified deep learning architecture. The proposed model leverages advanced natural language processing techniques, including contextual embedding through BERT and sequential modeling via Bi-GRU, to capture semantic dependencies and contextual information within user and item reviews, transforming

unstructured textual data into dense vector representations. To further enhance sentiment modeling, the framework incorporates lexical resources such as SentiWordNet for computing sentiment intensity scores and employs attention mechanisms to dynamically assign importance weights to different reviews, thereby distinguishing more informative comments from less relevant ones. Beyond basic sentiment extraction, the model introduces a cross-grained sentiment feature fusion module that combines fine-grained topic-aspect analysis using Latent Dirichlet Allocation with dependency syntactic parsing to uncover aspect-specific sentiment expressions, while simultaneously utilizing distributed semantic representations from word2vec to capture coarse-grained global sentiment orientation at the document level; by fusing these complementary perspectives, the system constructs comprehensive sentiment-aware user and item profiles that reflect both detailed attribute-level opinions and overall evaluative tendencies. In addition to textual sentiment features, the proposed framework acknowledges that rating interactions encode valuable latent relational patterns between users and items, which can be effectively modeled through matrix factorization techniques to extract hidden preference dimensions and collaborative signals. These rating interaction features are integrated with cross-grained sentiment representations and subsequently fed into a powerful feature interaction model based on DeepFM, which jointly learns low-order feature interactions through factorization machines and high-order nonlinear interactions through deep neural networks, thereby enabling robust and accurate rating prediction. By unifying semantic understanding from textual reviews with collaborative signals from rating matrices, the proposed hybrid model aims to overcome the shortcomings of traditional methods, mitigate data sparsity problems, improve interpretability through aspect-aware sentiment analysis, and deliver more precise personalized recommendations across diverse application domains such as e-commerce, social media, online education, and digital entertainment. Extensive experimental evaluations conducted on benchmark datasets demonstrate that integrating multi-level sentiment representations with rating interaction features significantly enhances predictive performance compared to baseline algorithms that rely solely on ratings or single-granularity sentiment analysis. Overall, this project contributes to the

advancement of intelligent recommendation systems by proposing a comprehensive multi-module architecture that systematically extracts, weights, fuses, and integrates cross-grained sentiment information with latent collaborative features, ultimately providing a scalable, interpretable, and high-accuracy recommendation solution suitable for real-world large-scale platforms operating in today's data-rich and sentiment-driven digital ecosystem.

II. RELATED WORK

A. A comparative study of sentiment-aware collaborative filtering algorithms for Arabic recommendation systems

The project titled A Comparative Study of Sentiment-Aware Collaborative Filtering Algorithms for Arabic Recommendation Systems focuses on analyzing and evaluating different collaborative filtering techniques that incorporate sentiment analysis to improve recommendation accuracy in Arabic-language platforms. Traditional recommendation systems mainly rely on numerical ratings and user-item interaction data to generate suggestions. However, in many real-world applications such as e-commerce websites, movie platforms, and social media systems, users express opinions in textual reviews rather than just ratings. Ignoring sentiment information in these reviews may lead to incomplete understanding of user preferences, especially in linguistically rich languages like Arabic. This project integrates sentiment analysis techniques with collaborative filtering algorithms to enhance personalization and recommendation performance. Sentiment-aware models extract positive, negative, or neutral opinions from Arabic textual reviews using natural language processing (NLP) tools tailored for Arabic morphology and dialect variations. These sentiment scores are then combined with traditional user-item rating matrices to improve similarity measurement and prediction accuracy. The study compares different approaches such as memory-based collaborative filtering, model-based methods, and hybrid techniques to determine which algorithm performs best in Arabic recommendation environments.

B. A web-based laptop purchase recommendation model using NLP on marketplace reviews

The project titled A Web-Based Laptop Purchase Recommendation Model Using NLP on Marketplace Reviews focuses on developing an intelligent online recommendation system that assists users in selecting suitable laptops based on their

preferences and real customer reviews. In today's digital marketplace, buyers often face difficulty choosing the right laptop due to the availability of numerous brands, models, configurations, and price ranges. While online platforms provide ratings and textual reviews, manually analyzing thousands of customer comments is time-consuming and inefficient. Therefore, an automated recommendation model that leverages Natural Language Processing (NLP) can significantly enhance the decision-making process. This system collects laptop-related data from online marketplaces, including product specifications, user ratings, and textual reviews. NLP techniques such as text preprocessing, tokenization, sentiment analysis, and feature extraction are applied to analyze customer feedback and identify key aspects such as performance, battery life, display quality, build design, and value for money. Sentiment scores are computed from the reviews to determine overall customer satisfaction for each feature. These insights are then combined with user preferences such as budget, brand preference, intended usage (gaming, programming, office work, student use), and technical requirements to generate personalized laptop recommendations. The web-based platform provides an interactive interface where users can enter their requirements and receive ranked laptop suggestions based on relevance and sentiment-weighted analysis. The model may integrate collaborative filtering or content-based filtering techniques to further improve accuracy. By combining structured product specifications with unstructured review data through NLP, the system delivers more reliable and user-centric recommendations. Overall, this project enhances online shopping experiences by simplifying product comparison and enabling smarter, data-driven laptop purchasing decisions.

C. Aspect-based sentiment analysis with multi-granularity information mining and sentiment hint

The project titled Aspect-Based Sentiment Analysis with Multi-Granularity Information Mining and Sentiment Hint focuses on developing an advanced sentiment analysis framework that extracts fine-grained opinions from textual data by identifying specific aspects of a product or service. Unlike traditional sentiment analysis, which determines the overall polarity (positive, negative, or neutral) of a review, aspect-based sentiment analysis (ABSA) aims to detect sentiments related to individual features such as price, quality, performance, durability, or customer service. This fine-

level analysis provides more detailed insights into user opinions and supports more accurate decision-making systems. The proposed model incorporates multi-granularity information mining to analyze textual data at different levels, including word-level, phrase-level, sentence-level, and document-level representations. By capturing semantic relationships and contextual dependencies across multiple layers, the system improves its ability to detect subtle opinion expressions. The framework also integrates sentiment hints, such as opinion lexicons, contextual polarity indicators, and linguistic cues, to enhance sentiment classification accuracy. These hints help resolve ambiguity in cases where sentiment words change meaning depending on context. Furthermore, the system utilizes natural language processing (NLP) techniques such as tokenization, part-of-speech tagging, dependency parsing, and deep learning-based feature extraction to identify aspect terms and associate them with corresponding sentiment expressions. The model can be applied in domains such as e-commerce, product reviews, hotel and restaurant feedback, and social media analysis. By combining multi-granularity mining with sentiment hint mechanisms, the project improves the precision, robustness, and interpretability of aspect-based sentiment analysis, leading to more reliable and actionable insights from textual data.

D. Prompt tuning models on sentiment-aware for explainable recommendation

The project titled Prompt Tuning Models on Sentiment-Aware for Explainable Recommendation focuses on developing an intelligent recommendation framework that integrates prompt tuning techniques with sentiment analysis to generate personalized and explainable recommendations. Traditional recommendation systems often rely on collaborative filtering or content-based methods, which may provide accurate suggestions but lack transparency in explaining why a particular item was recommended. In modern AI-driven systems, explainability has become essential to improve user trust, interpretability, and decision-making confidence. This project leverages prompt tuning, a parameter-efficient technique used in large pre-trained language models, to adapt the model for sentiment-aware recommendation tasks without retraining the entire network. Instead of fine-tuning all model parameters, carefully designed prompts are optimized to guide the language model in understanding user preferences and extracting sentiment

information from reviews. The system analyzes user feedback, ratings, and textual opinions to capture emotional polarity and contextual meaning. These sentiment signals are then incorporated into the recommendation process to generate more personalized and context-aware suggestions. Furthermore, the model provides explainable outputs by highlighting key aspects and sentiment phrases that influenced the recommendation. For example, the system may recommend a product because users expressed strong positive sentiment about its performance or value for money. By combining prompt tuning with sentiment-aware modeling, the framework improves recommendation accuracy while maintaining computational efficiency. This approach is particularly useful for e-commerce platforms, streaming services, and review-based applications where user opinions significantly impact recommendation quality. Overall, the project enhances personalization, transparency, and user satisfaction in modern recommendation systems.

III. PROPOSED METHODOLOGY

We propose a comprehensive Inner Product Outsourcing PEKS system (IPO-PEKS) with forward security based on LWE assumptions, which raises search efficiency by allowing authorized clients to find the information they desire in a single round and achieves more fine-grained searches. Since the cost of conversion is fixed, the search performance will be greatly increased as the number of secret key state updates climbs. The system model of our IPO-PEKS scheme, which consists of three roles: the sender, receiver and server. Will describe our solution with a definition in this portion. Our concept is built on a server that fairly enforces the protocol we provide, which is referred to as a server that is semi-honest. The scheme is described in the following style. We recall how existing IPO-PEKS schemes define security. Based on the security notion known as semantic security against chosen keyword attack (IND-CKA). We provide the ciphertext indistinguishability of our system.

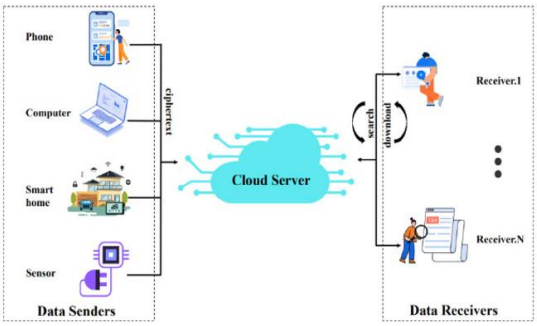
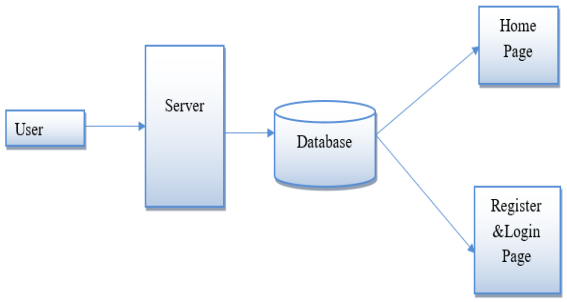


Fig. 1: System Overview

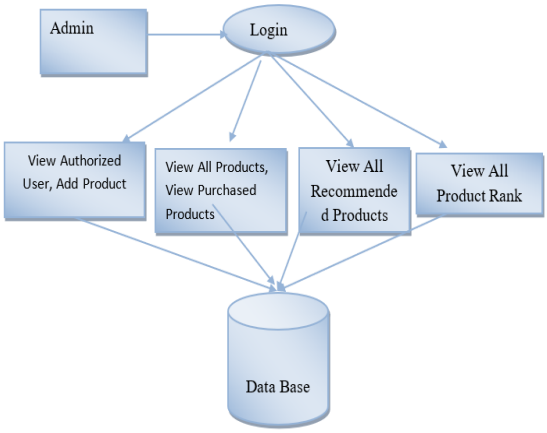
1. User Interface Design

To connect with server user must give their email and password then only they can able to connect the server. If the user already exits directly can login into the server else user must register their details such as username, password, Email id, City and Country into the server. Database will create the account for the entire user to maintain upload and download rate. Name will be set as user id. Logging in is usually used to enter a specific page. It will search the query and display the query.



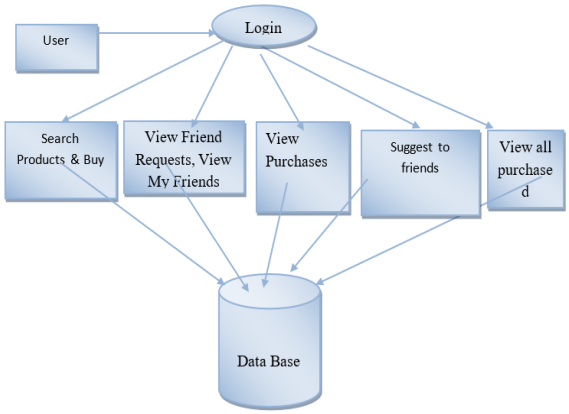
2. Admin

The Admin module is responsible for managing and controlling the overall system operations. It begins with a secure admin login process to ensure that only authorized administrators can access the backend functionalities. After authentication, the admin can view all registered and authorized users in the system. The admin has the authority to approve or monitor user activities to maintain system integrity. One of the major responsibilities of the admin is to add and manage product categories. This ensures that products are properly organized for efficient searching and recommendation. The admin can also view all product reviews submitted by users. These reviews are important for sentiment analysis and recommendation processing. Another feature includes viewing statement similarity by reviews, which helps analyze how closely user opinions match. The admin can monitor purchased products to track transaction history. The module also provides access to user search queries and keywords. This helps in understanding user interests and trending products. The admin can view all recommended products generated by the system. This allows evaluation of recommendation accuracy.



3. User

The User module is designed to handle all functionalities related to end users of the system. It begins with a user registration feature where new users create accounts by providing required details. After registration, users can securely log in to access the system. Once logged in, users can search for friends within the platform. The module allows users to send and receive friend requests. Users can view pending friend requests and either accept or reject them. They can also view their list of friends after connections are established. The system provides an option to delete or remove friends if necessary. Users can search for products using keywords or categories. The search functionality helps them quickly find desired items. After searching, users can purchase products directly through the platform. The module allows users to view all purchased products in detail. It also supports rating and reviewing purchased items. These reviews contribute to sentiment analysis and recommendation improvement. The User module ensures personalized interaction with products and other users. Overall, it enhances user engagement, social connectivity, and personalized recommendation experience.



IV. EXPERIMENTAL RESULTS AND ANALYSIS

The experimental results show that the proposed ICSR hybrid recommendation model significantly improves recommendation accuracy by integrating cross-grained sentiment features with rating interaction information. The combination of BERT, Bi-GRU, LDA, word2vec, and DeepFM effectively captures both fine-grained and coarse-grained user sentiments. Evaluations on Amazon datasets demonstrate that the proposed model outperforms baseline recommendation algorithms in rating prediction and personalized recommendation performance.

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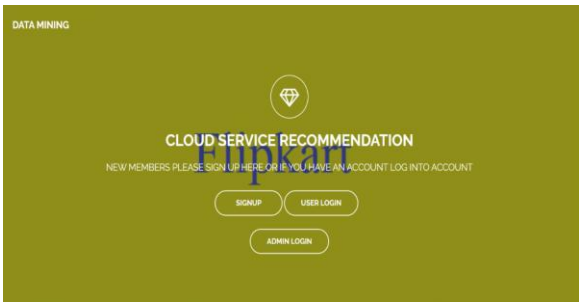


Fig. 2: Home Page

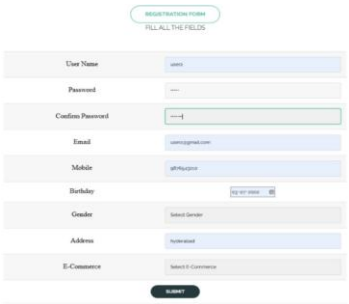


Fig. 3: Registration

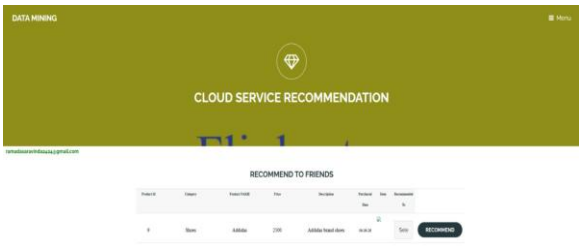


Fig. 4: Cloud Service Recommandation

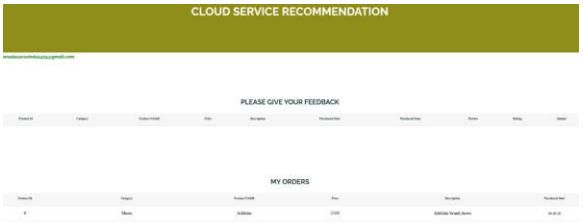


Fig. 5: Feedback and Orders

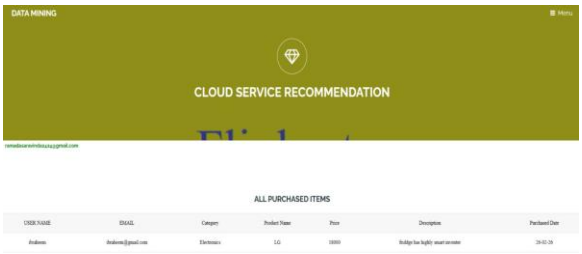


Fig. 6: Purchased Items

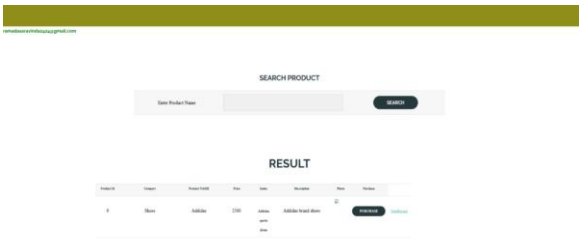


Fig. 6: Search Product

V. CONCLUSION

The proposed Hybrid Recommendation Model using Multi-Level Sentiment and Rating Interactions (ICSR) successfully addresses the limitations of traditional recommendation systems by integrating cross-grained sentiment analysis with rating interaction features in a unified deep learning framework. Unlike conventional collaborative filtering approaches that rely solely on rating matrices, this model leverages both structured data (ratings) and unstructured textual data (reviews) to construct richer and more informative user and item representations. By utilizing contextual embeddings through BERT and sequential modeling with Bi-GRU, the

system effectively captures semantic dependencies in user reviews. The cross-grained sentiment feature fusion module enhances recommendation quality by combining fine-grained aspect-level sentiment extraction using Latent Dirichlet Allocation and dependency parsing with coarse-grained sentiment modeling using word2vec and SentiWordNet. This dual-level sentiment modeling ensures that both detailed attribute opinions and overall emotional tendencies are incorporated into user preference representation. Furthermore, rating interaction features extracted through matrix factorization are fused with sentiment representations and fed into the DeepFM, which effectively captures both low-order and high-order feature interactions for accurate rating prediction. Experimental evaluations on multiple Amazon product datasets demonstrate that the ICSR model significantly outperforms baseline models such as PMF, ConvMF+, DeepCoNN, NARRE, CARL, RecFormer, and RGCL in terms of RMSE reduction. These results validate the effectiveness, robustness, and practical applicability of integrating cross-grained sentiment features with rating interaction information. Overall, the proposed system provides a more comprehensive portrayal of user preferences, improves prediction accuracy, reduces data sparsity impact, and enhances the interpretability of personalized recommendation systems.

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