Draft Master's Thesis Proposal

Pavan Singh - MSc Advanced Analytics

A Multi-Modal Hybrid Neural Collaborative Recommender System.

A Summary of Topic

- **Multi-Modal**: integrate text and ratings data
- **Neural**: use Neural Collaborative filtering to predict user-item ratings
- **Hybrid**: use both collaborative and content-based filtering

Essentially the idea is to build a multi-modal neural collaborative filtering recommender system which is hybrid in design. The dataset used is the Amazon Reviews Dataset. We shall take the text and ratings data, use NLP and a Neural Collaborative filtering approach together with a traditional content based approach to build our ensemble recommender model. We evaluate our model performance and compare it to other baseline models such as the popular Matrix Factorisation methods and Memory-based methods for Recommender Systems. Can also compare performance of the model with and without text data incorporated into model.

The goal/idea is to explore the applications of text in generating better recommendations. Hybrid Recommender systems, Neural collaborative filtering, and NLP in RS have been studied before individually – the combination of all three have not.

Table of Contents

Introduction

We cover some background to the study, the problem at hand, the research objective and the potential significance of the study.

Background of the Study

Online shopping has become a ubiquitous aspect of modern life, and recommender systems have become a crucial tool for e-commerce platforms such as Amazon. Recommender systems aim to provide users with personalized product recommendations based on their preferences and behaviours. They analyse user data, such as their browsing history, purchase history, and ratings, to understand their preferences and make recommendations that align with those preferences. They have become fundamental applications in electronic commerce and information access, providing suggestions that effectively prune large information spaces so that users are directed toward those items that best meet their needs and preferences. However, traditional recommender systems have several limitations which we can seek to overcome.

Recent advances in machine learning and artificial intelligence have led to the development of hybrid recommender systems, which combine multiple recommendation algorithms to overcome these limitations. One such approach is the multimodal neural collaborative filtering hybrid recommender system, which uses neural networks to combine information from multiple modalities, such as text, images, and ratings, to make more accurate recommendations.

In this study, the aim is to evaluate the performance of a multimodal neural collaborative filtering hybrid recommender system on the Amazon reviews dataset. The study will address the limitations of traditional recommender systems and explore the potential of multimodal neural networks for improving the accuracy and transparency of product recommendations in the e-commerce domain.

Statement of the Problem and Objective

Despite the widespread use of recommender systems in e-commerce platforms, traditional recommender systems have several limitations that can impact the accuracy and usefulness of product recommendations. These limitations include a **lack of transparency** in the recommendation process, **cold-start problems** for new users or products, and the **inability to handle multiple types of information**, such as text and images. Additionally, many traditional recommender systems rely on a single recommendation algorithm, which can limit the accuracy of recommendations. In order to address these limitations, there is a need for a more advanced recommendation system that can effectively leverage multiple modalities of information to provide more accurate and relevant product recommendations.

The aim of this study is to address the limitations of traditional recommender systems by evaluating the performance of a multi-modal neural collaborative filtering hybrid recommender system on the Amazon reviews dataset. The study will explore the potential of combining multiple recommendation algorithms, including collaborative filtering and neural networks, to provide more accurate and relevant product recommendations, and to make the recommendation process more transparent.

Brief Review of Previous Studies

- **No in-text referencing in this draft**
- **Articles for the research paper have been cited at the end of proposal**

Recommender systems are increasingly being used in e-commerce platforms to provide personalized recommendations to customers, to help them go through the platforms product catalogue and get them to what they want to see.

There has been a lot of research in this space as available data has grown exponentially, and a platforms seek ways to ensure their customers enjoy a satisfactory experience – getting and viewing products/content they are likely wanting to see. The field is generally made up of three types of algorithms, including content-based, collaborative filtering Collaborative filtering, which is based on the preferences of users and items, is one of the most widely used recommendation algorithms. To improve performance, these methods have sometimes been combined in hybrid recommenders. **Hybrid recommender systems**, which combine multiple recommendation algorithms, have been shown to outperform individual algorithms in many cases

With the idea of improving Recommender Models, there has been a lot of growth in incorporating data of different modalities. **Multimodal recommender systems** use multiple types of information such as text, images, and ratings, have emerged as a promising approach to provide more accurate and relevant recommendations. The different types of data that can be recorded for a single individual, for example, can be compiled and leveraged to improve the quality of predictions in recommender systems.

From a **deep learning** perspective. The rapid advancements in neural networks and machine learning has made steadily made its way into the field of recommender systems. Neural networks, including feedforward and recurrent neural networks, have been applied in recommender systems to learn complex relationships between users and items. Papers have irrevocably claimed that Neural network applications in Matrix factorisation in Collaborate filtering have improved the performance of CF systems in both the recommendation quality and efficiency.

In general, a review of the literate seems to claim that application of deep learning, multi-modal model and hybrid systems, individually, improve the performance of recommender systems. The gaol of this paper is to leverage each of these three approaches into one model and benchmark the performance of this configured model against their individual counterparts and/or other traditional methods in providing recommendations.

Overview of Methodology and Process

We seek to take text and ratings data, fuse the data. We can do this by turning the text data into a bag of words model or another similar NLP approach. This may include removing stop words, stemming or lemmatizing the words, and converting the words to numerical representations such as term frequency-inverse document frequency (TF-IDF) or word embeddings. We can then use this data as inputs to our models. The ensemble approach can be broken down into three steps:

(1) neural network collaborative filtering model
    a. Train a neural network collaborative filtering model on the ratings and/or text data. This model will generate recommendations based on the similarity between the items and users.

(2) Content-based recommender system
    a. Train a content-based recommendation model on the data. This model will generate recommendations based on the similarity between the items and the items that users have previously rated.

(3) Results Fusion
    a. Results Fusion: Combine the results from both models to form a hybrid model. This can be done in several ways, including:
        i. Averaging the scores generated by each model
        ii. Weighting the scores generated by each model based on their performance
        iii. Selecting the recommendation from the model with the highest score for each user-item pair
        iv. Using a neural network

After we have configured our ensemble model, we can evaluate the performance of the hybrid model using appropriate metrics, such as precision, recall, and F1-score. Compare the performance of the hybrid model with the performance of each individual model to determine the effectiveness of the fusion method

From here we shall process the data In each model and ensemble the result to generate a combined prediction.

Model 1: Neural Collaborative Filtering Model

The neural network component of the problem can play several faces:

1. In a Neural Collaborate filtering approach: uses neural networks to model the relationships between the users and items. Instead of factorizing the interaction matrix → NCF directly learns the representations of the users and items through the neural network.

2. In a Deep Matrix Factorisation: combination of matrix factorisation and deep learning, where a deep neural network is used to factorise the user-item interaction matrix into low-dimensional representations of the users and items. This method is very computationally taxing.

3. We could use a neural network to combine the results from multiple recommender systems. This can be used to provide recommendations based on a combination of different algorithms, such as collaborative filtering and content-based filtering.

We opt to use neural collaborate filtering approach.

Model 2: Content-based Filtering

After pre-processing the text data, we can proceed to represent each item as a feature vector that combines information from the ratings data and the text data. Calculate the similarity between the items and users using similarity measures like cosine similarity. We. Can then generate recommendations for each user by selecting the items that are most similar to the items that the user has previously rated.

Final Model

As discussed to reach and possibly generate an improved recommendation, we shall seek to combine the results from the two models, 1 and 2. The method or approach of combining these models can vary, and be tested. The resulting model predictions can be evaluated and benchmarked against other traditional models

Data

The Amazon reviews dataset is a rich source of information that can be used to build a recommender system. The dataset includes customer reviews, ratings, and other information related to products sold on the Amazon platform. As such it is a good resource for studying and applying collaborative filtering-based recommendations and hybrid systems that incorporate content-based filtering. Its various feature set also makes it suitable for multi-modal applications.

Using this dataset to build a recommender system that leverages the advantages of neural collaborative filtering and multimodal information has the potential to significantly improve the accuracy and usability of product recommendations for Amazon users.

Moreover it serves as the perfect dataset resembling the data required to be processed and handled by configured recommender systems in large e-commerce platforms.

Schedule

Feb-March	April-May	June-July	August	September	October
Finalize research questions and hypotheses. Conduct a comprehensive literature review. Define the scope and methodology of the study.	Collect and pre-process the Amazon reviews dataset Develop the multimodal neural collaborative filtering hybrid recommender system	Evaluate the performance of the recommender system using various metrics Compare the results with those of other recommender systems.	Analyse the results of the study Identify the strengths and weaknesses of the recommender system Provide suggestions for future work.	Write the first draft of the thesis. Including the introduction, background of the study, statement of the problem, literature review, methodology, results, and conclusion	Revise the thesis based on feedback from the advisor and peers, and finalize the writing

References & Research Papers

Hybrid Models

Burke, R. Hybrid Recommender Systems: Survey and Experiments. *User Model User-Adap Inter* **12**, 331–370 (2002). https://doi.org/10.1023/A:1021240730564

Multi-modal Models

Arthur F. da Costa, Marcelo G. Manzato, Exploiting multimodal interactions in recommender systems with ensemble algorithms, Information Systems, Volume 56, 2016, Pages 120-132, ISSN 0306-4379, https://doi.org/10.1016/j.is.2015.09.007

Deep Learning in Recommender Systems

Shuai Zhang, Lina Yao, Aixin Sun, and Yi Tay. 2019. Deep Learning Based Recommender System: A Survey and New Perspectives. ACM Comput. Surv. 52, 1, Article 5 (January 2020), 38 pages. https://doi.org/10.1145/3285029

Recommender Systems

Linyuan Lü, Matúš Medo, Chi Ho Yeung, Yi-Cheng Zhang, Zi-Ke Zhang, Tao Zhou, Recommender systems, Physics Reports, Volume 519, Issue 1, 2012, Pages 1-49, ISSN 0370-1573, https://doi.org/10.1016/j.physrep.2012.02.006.