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Fashion Recommendation Systems

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1. Literature review

In recent years, the textile and fashion industries have witnessed an enormous amount of growth in fast fashion. On e-commerce platforms, where numerous choices are available, an efficient recommendation system is required to sort, order, and efficiently convey relevant product content or information to users. Image-based fashion recommendation systems (FRSs) have attracted a huge amount of attention from fast fashion retailers as they provide a personalized shopping experience to consumers. With the technological advancements, this branch of artificial intelligence exhibits a tremendous amount of potential in image processing, parsing, classification, and segmentation. Despite its huge potential, the number of academic articles on this topic is limited. The available studies do not provide a rigorous review of fashion recommendation systems and the corresponding filtering techniques. To the best of the authors' knowledge, this is the first scholarly article to review the state-of-the-art fashion recommendation systems and the corresponding filtering techniques. In addition, this review also explores various potential models that could be implemented to develop fashion recommendation systems in the future. This paper will help researchers, academics, and practitioners who are interested in machine learning, computer vision, and fashion retailing to understand the characteristics of the different fashion recommendation systems.

Keywords: fashion recommendation system; e-commerce; filtering techniques; algorithm; performance

Analyzing consumers' choices and recommendations is valuable to fashion designers and retailers. Additionally, consumers' clothing choices and product preference data have

become available on the Internet in the form of text or opinions and images or pictures. Since these images contain information about people from all around the world, both online and

offline fashion retailers are using these platforms to reach billions of users who are active on the Internet. Therefore, e-commerce has become the predominant channel for shopping in recent years. The ability of recommendation systems to provide personalized recommendations and respond quickly to the consumer's choices has contributed significantly to the expansion of e-commerce sale According to different studies, e-commerce retailers, such as Amazon, eBay, and Shop style, and social networking sites, such as Pinterest, Snapchat, Instagram, Facebook, Chictopia, and Look book, are now regarded as the most popular media for fashion advice and recommendations. Research on textual content, such as posts and comments, emotion and information diffusion, and images has attracted the attention of modern-day researchers, as it can help to predict fashion trends and facilitate the development of effective recommendation systems. An effective recommendation system is a crucial tool for successfully conducting an e-commerce business. Fashion recommendation systems (FRSs) generally provide specific recommendations to the consumer based on their browsing and previous purchase history. Social-network-based FRSs consider the user's social circle, fashion product attributes, image parsing, fashion trends, and consistency in fashion styles as important factors since they impact upon the user's purchasing decisions. FRSs have the ability to reduce transaction costs for consumers and increase revenue for retailers. With the exception of a single study from 2016 that focuses only on apparel recommendation systems, no current research presents recent advances in research on fashion recommendation systems. Therefore, the purpose of this paper is to present an integrative review of the research related to fashion recommendation systems. Moreover, Guan et al. cited research published until 2015. Therefore, the first objective of this paper is to review the most recent research published on this topic from 2010 to 2020. The previous study did not provide an in-depth analysis of the computational methods or algorithms corresponding to the fashion recommendation systems. This review study aims to full-fill this research gap and rigorously study the principles underlying, the methods used by, and the performance of the state-of-the-art fashion recommendation systems. To the best of our knowledge, this in-depth study is first of its kind. It includes research articles related to image parsing, clothing and body shape identification, and fashion attribute recognition, which are critical parts of fashion recommendation systems (FRSs).

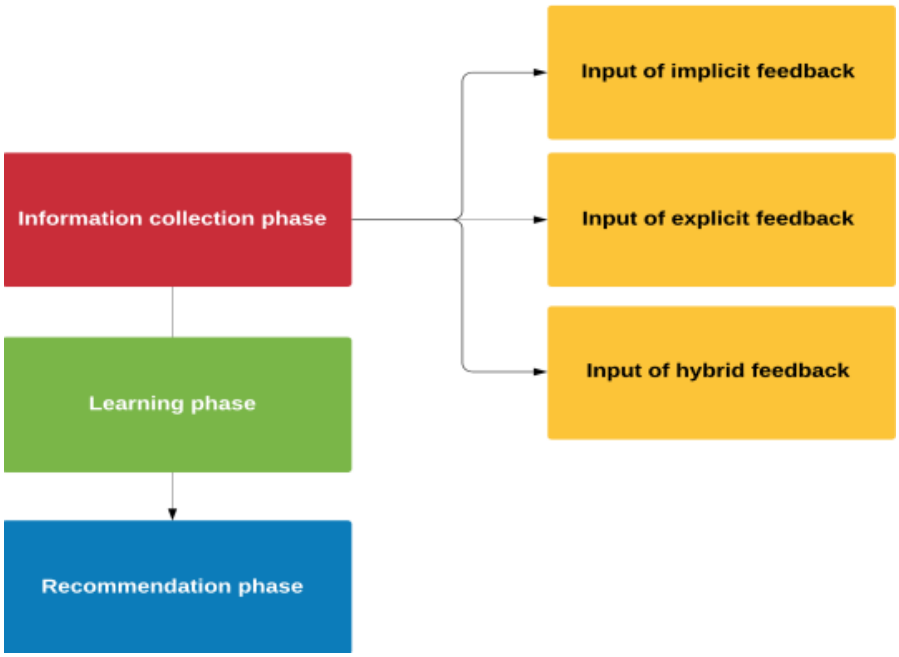
2. History and Overview of Recommendation System

The era of recommendation systems originally started in the 1990s based on the widespread research progress in Collective Intelligence. During this period, recommendations were generally provided to consumers based on their rating structure. The first consumer-focused recommendation system was developed and commercialized by Goldberg, Nichols, Oki and Terry in 1992. Tapestry, an electronic messaging system was developed to allow users only to rate messages as either a good or bad product and service. However, now there are plenty of methods to obtain information about the consumer's liking for a product through the Internet. These data can be retrieved in the forms of voting, tagging, reviewing and the number of likes or dislikes the user provides. It may also include reviews written in blogs,

videos uploaded on YouTube or messages about a product. Regardless of communication and presentation, medium preferences are expressed in the form of numerical values.

2.1. Recommendation System

Recommendation system (RS) is referred to as a decision-making approach for users under a multidimensional information environment. RS has also been defined as an e-commerce tool, which helps consumers search based on knowledge that is related to a consumer's choices and preferences. RS also assists in augmenting social processes by using the recommendations of other users when there is no abundant personal information or knowledge of the alternatives. RS handles the complication of information overload that consumers usually encounter by offering customized service, exclusive content, and personalized recommendations. There are multiple phases involved in the recommendation system that develop the foundation of any state-of-the-art recommendation system. These are defined as the information collection phase, the learning phase, and the recommendation phase. Figure 2 shows the interrelationship of these phases involved in the recommendation process. It shows that information collection is the initial stage of RS, which is followed by the learning phase and the recommendation phase. The recommendation provided in the last phase can be generated based on information gathered during the information collection phase.



3. Information Collection Phase

In this phase a user's relevant information is collected to develop a user profile or model based on the user's characteristics, behaviors, and the content of the resources they have browsed, which are applicable in prediction phase tasks. The accurate functioning of a recommendation agent depends on the proper construction of a user profile or model. The system can offer a quick yet appropriate recommendation when it has all the required information about the user. Thus, the success of a recommendation or recommender system largely depends on the ability of the model to denote users' current preferences or choices. The foundation of the recommendation system relies on three types of input such as explicit feedback, implicit feedback, and hybrid feedback. Explicit feedback needs to be of high quality as it encompasses users' explicit input regarding their interest in or choice of a product. The accuracy of the prediction or recommendation relies on user ratings. Therefore, if the users do not provide enough information, it limits the accuracy of the system. Despite this requirement, explicit feedback is still considered a crucial information input process as it provides more reliable data and builds transparency into the recommendation procedure. Implicit feedback is also important in understanding users' preferences, which are inferred indirectly through observation of user behavior. Although this method does not require the same effort from the users, it is often seen as less accurate. Hybrid feedback is considered a combination of explicit and implicit feedback. It can be accomplished by utilizing the implicit feedback data as a check on the explicit feedback rating or by providing users with the opportunity to give feedback only if they choose to explicitly express their interest.

3.2 Learning Phase

A learning algorithm is applied in this phase to filter and exploit the users' features based on the feedback collected in the information collection phase. The learning algorithms used in this phase are helpful for drawing out the appropriate patterns relevant for application during the recommendation stage.

3.3. Recommendation Phase

The recommendation phase recommends the types of items that a user or consumer may prefer. Recommendations can be provided either directly based on the dataset collected during the information collection phase (which might be memory- or model-based) or through the browsing history of users observed by the system. Recommendations can also be provided by combining the learned information with the rating matrix to recommend learning resources. Researchers reported improved recommendation accuracy using hybrid models in comparison with product content-based or other user preference-based collaborative models.

4. Classification of Fashion Recommendation System (FRS)

Fashion recommendation systems (FRS) proposed by researchers vary from each other based on the filtering techniques used, information collection and learning procedures, feature extraction methods and types of recommendations provided to users or consumers. The paper has categorized the recommendation systems into five classes such as fashion image

retrieval, a personal wardrobe recommendation system, a knowledge-based recommendation system, smart or intelligent recommendation systems and a social-network based recommendation system based on previous research and academic articles. These recommendation systems or approaches have been discussed briefly in Table 2 A fashion image retrieval system is formulated based on clusters of fashion products and their feature similarity as well as correlation analysis based on individual historical data. Personal wardrobe recommendation systems explore similar fashion styles based on wardrobe usage history. Fashion pairing recommendation systems, also referred to as fashion coordination systems, are based on the rules of matching different types of clothing items with styling knowledge. A smart or intelligent recommendation approach uses features or attributes of the clothing and user in terms of users' body shapes, contextual information of wear, outfit type and genre characteristics. A social-network-based recommendation approach offers recommendations to many social-media-based information discovery and social collaborations among potential collaborators using social networking features. Sachdeva and Pandey (2020) focused on the analysis of patterns for different consumer groups with finely grained fashion elements using a large-scale fashion trend dataset (FIT) compiled from Instagram reports. The usage details were provided to the Knowledge Enhanced Recurrent Network model (KERN), which takes advantage of the capacity of deep recurrent neural networks to model time series of fashion elements, considering very complex patterns effectively.

5. Discussion

This scholarly article has provided a comprehensive review of the methods, algorithmic models and filtering techniques used in the recent fashion recommendation-based research papers. However, this review paper has some limitations too. Primarily, the focus of this comprehensive review paper was to explore fashion recommendation-based articles published in last decade that explicitly described their frameworks, algorithms, and filtering techniques. To achieve this goal, the articles were searched using keywords relevant to the topic title instead of using the PRISMA technique. However, it did not affect the article extraction methodology, because the authors included and studied all the research papers relevant to the research focus. However, future researchers could conduct a systematic literature review on the same topic. The initial keyword searching did not include "garment" and "outfit"; however, this did not influence the search results because we also studied the fashion recommendation articles that contained these keywords. The future research can also conduct a review of the datasets that have been used in fashion recommendation-based research articles. Additionally, further reviews of fashion recommendation systems can apply our proposed potential algorithms to any of the available fashion image datasets to evaluate the performance of the recommender systems.

6. Conclusions

Recommendation systems have the potential to explore new opportunities for retailers by enabling them to provide customized recommendations to consumers based on information retrieved from the Internet. They help consumers to instantly find the products and services that closely match with their choices. Moreover, different stat-of-the-art algorithms have

been developed to recommend products based on users' interactions with their social groups. Therefore, research on embedding social media images within fashion recommendation systems has gained huge popularity in recent times. This paper presented a review of the fashion recommendation systems, algorithmic models and filtering techniques based on the academic articles related to this topic. The technical aspects, strengths and weaknesses of the filtering techniques have been discussed elaborately, which will help future researchers gain an in-depth understanding of fashion recommender systems. However, the proposed prototypes should be tested in commercial applications to understand their feasibility and accuracy in the retail market, because inaccurate recommendations can produce a negative impact on a customer.

Author Contributions:

S.C.: Conceptualization, Methodology and Writing—Original Draft Preparation; M.S.H.: Conceptualization, Methodology and Writing—Original Draft Preparation; N.R.J.: Writing—Original Draft Preparation and Writing—Reviewing and Editing; M.C.B.: Methodology and Writing—Reviewing and Editing; D.B.: Writing—Original Draft Preparation and Writing—Reviewing and Editing, E.L.: Supervision; Writing—Reviewing and Editing. The authors approved the manuscript and agreed with the submission to the Informatics journal. All authors have read and agreed to the published version of the manuscript.

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