

Towards Sustainable Living via Green Recommendation Systems

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Abstract

The Internet revolution has fueled the growth of e-commerce and the adoption of a digital lifestyle globally. Simultaneously, there is increased attention to issues of sustainability in all human activities from various sectors including business, society, and governing bodies. Daily living activities, including online shopping, food consumption, and transportation, may leave carbon footprints in various ways and are therefore also subject to the growing expectations of sustainability. On the one hand, companies are expected to be mindful of their environmental impact and to publicly report on their sustainable practices. On the other hand, consumers, who are becoming more environmentally conscious, are seeking out products and services with lower environmental impact and higher sustainability. Recommender systems play a critical role in the modern digital lifestyle as they can help consumers navigate through numerous offerings and find their preferred products and services. By recommending “greener” products, services and practices, recommender systems have a great potential to shape more sustainable living styles and encourage more product and service providers to pursue an environmental competitive advantage.

In this paper, we explore approaches to make recommendations more environmentally sustainable and provide a framework for future research on promoting sustainable lifestyles with recommendations. We first outline several challenges in recommendation systems from the sustainability

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aspect. Then, we propose a green recommendation paradigm, which helps users lead sustainable lives under four scenarios.

Keywords: Green Recommendation, Sustainable Living.

I. Introduction

The widespread adoption of Internet technologies has created numerous opportunities for people worldwide to participate in e-commerce and enjoy a convenient digital lifestyle [12, 6]. This trend has been further accelerated by the COVID-19 pandemic. At the same time, sustainability has been a significant research topic over years, which addresses the interconnected challenges of environmental, social, and economic well-being [10]. There is a growing awareness and action on sustainability issues at all levels, from individuals and businesses to governments and international organizations [3].

Daily living activities, such as online shopping, food consumption, and transportation, may leave carbon footprints in various ways. Carbon emissions from these activities may include but are not limited to the production, processing, and refining of food and commodities, as well as the packaging and logistics involved in the delivery of products and services [7]. With the increasing adoption of a modern digital lifestyle, customers with increased environmental awareness now demand green shopping experiences and more sustainable living options [1]. As a result, it's crucial for businesses to take sustainability into consideration in order to attract and retain customers [11]. The Internet has penetrated and transformed many facets of our daily living, making sustainability an integral part of the discussion of a modern lifestyle.

Recommender systems are increasingly utilized by e-commerce sites to help consumers find

products to purchase [17, 8, 13, 14]. Initially considered a novelty in the online shopping experience, these systems have evolved into vital business tools. The technology employs either expert-supplied manually coded product knowledge or knowledge obtained through mining consumer behaviour to navigate consumers through the daunting task of finding products they will enjoy. Green recommendation systems may lead a new way to sustainable living by recommending environmentally friendly or reusable products, eco-friendly travel, and energy-efficient living patterns in buildings. Previous studies have verified that green product recommendations not only can reduce energy consumption and greenhouse gas emissions [2] but also can shape a sustainable consumption pattern for consumers [4]. Thus, achieving sustainable living and e-commerce via green recommendation systems has both social and economic impacts, as it can steer the behavior of individuals towards sustainable lifestyles, create local green markets for sustainable products, and encourage the product and service providers to pursue a competitive environmental advantage. It may drive a green revolution in e-commerce from downstream to upstream, by influencing the practices of product and service providers by shaping greener customer choices.

Although it is feasible to build green recommendation systems on e-commerce platforms, such as Taobao, which have accumulated a large-scale of consumer consumption behaviors and items, several key challenges should be addressed from a sustainable perspective.

- **Sustainable product identification.** Considering the large volume of daily added commodities on e-commerce platforms, such as Taobao, it would be challenging to identify the sustainability characteristics of commodities based on their produce/use/disposal of life cycles without investing more time and elbow grease.
- **Multi-criteria optimization for a personalized recommendation.** Conventional recom-

mendation systems usually target to optimize the criterion of recommendation accuracy. However, green recommendation models are required to optimize multi-criteria. Because consumers' preferences towards sustainable living depend on both ecological perspectives and their evaluation of various recommended item (product/food/travel/behaviour) properties. Thus, it is a challenge to personalize the recommendation of green items to end-consumers.

- **Incentive mechanisms for green item (product/food/travel/behaviour) adoption.** As the prices of green item alternatives are typically higher than conventional ones [5], various methods such as tax waivers or green advertising are explored to improve green item adoption [9]. However, it is still unclear how to incentivize end-users to adopt green items in recommendation systems.
- **Cross-scenario green recommendations.** Personal data may be observed from multiple scenarios, how to fuse these data and make recommendations in other scenarios would be challenging.
- **Sustainable recommendation algorithms.** Existing recommendation algorithms attempt to use large-scale neural networks trained on user-item interactions from scratch. The massive computation required for the technical feats of these algorithms comes at a cost, with high financial and environmental costs due to the large amount of energy consumed [15]. On the one hand, it is urgent to enhance and optimize the computational efficiency of cloud computing centers to achieve low-carbon high arithmetic power. On the other hand, we should harness the computational capabilities of edge devices to learn edge-cloud collaborative recommendations [16].

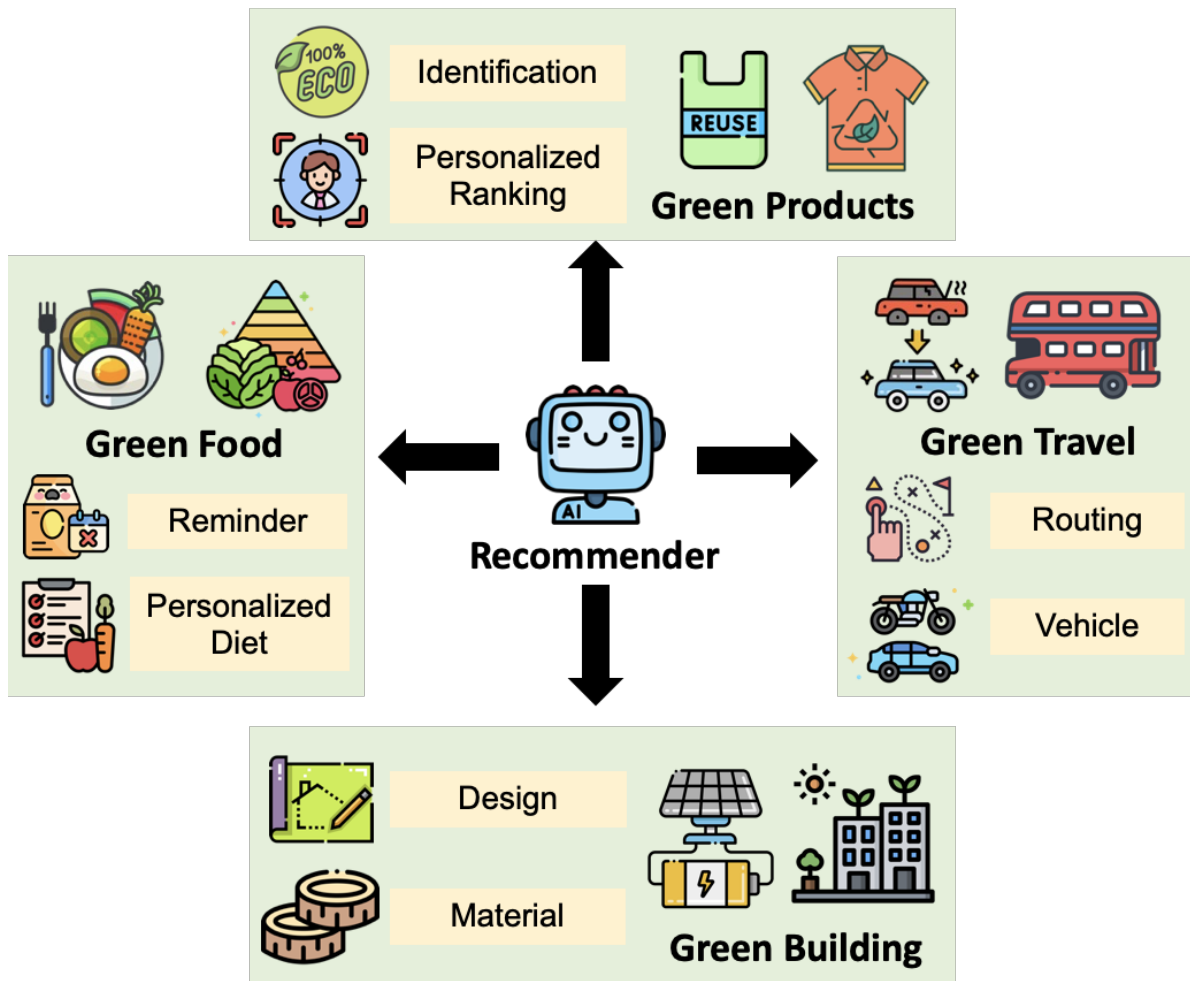


Fig 1 Overview of the proposed paradigm for the green recommendation.

II. Methods

We illustrate the overview of the green recommendation system applied in four scenarios to achieve sustainable living in Figure 1. We first elaborate on each recommendation scenario and then introduce potential ways to make the recommendation algorithm more sustainable.

First, we propose **Green Products**, where we recommend and guide consumers to purchase green commodities and aim to increase the supply and penetration of green-certified commodities on the platform. The increasing exposure of sustainable goods in the green recommendation system would increase consumers’ awareness and adoption of sustainable goods. Two main aspects are

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addressed: flexible identification of the sustainability attributes of platform commodities to achieve effective green product segmentation; and personalized recommendation of products that match users' ecological perceptions based on their preferences.

Second, **Green Food** is also a promising application area. Aiming at reducing food waste or becoming zero waste on food, we remind consumers to enjoy their previously purchased food before the expiration date with customized sustainable dietary recommendations. Such diets may deliver health and environmental benefits by suggesting partially replacing animal products with plant-based foods. Hence, adopting sustainable diets may play an important role in achieving sustainable living.

Third, we propose **Green Travel** to recommend routing and vehicle recommendations for daily transportation. We expect our model can identify the in situ demands of travelers automatically, such as time-sensitive or cost-sensitive travels. The recommendation will be conducted based on context demands as well as user preferences. However, for green travel, the model will be trained by biasing towards public transport or walking, which targets to connect people to destinations and nature, to honor social and environmental diversity.

Forth, **Green Buildings** are very important in our daily lives. In this scenario, we aim to develop energy-saving recommendation systems that put humans at the center of the decision-making process for energy-efficient buildings. The main objective is to recommend actions that minimize the energy footprint of occupants regarding the balance between user comfort and energy efficiency. While the majority of studies incorporate renewable and sustainable energy resources for green buildings, we study how recommendation systems could shape occupants' energy consumption behaviors and trim their wasted energy, which targets sustainable living.

To build **Green Recommendation Methods**, we list the following two potential directions.

First, leveraging pretrained models based on the multimodal information of items for recommendation. This will ease the burden of training a recommendation model from scratch and can significantly reduce the training cost. Also, we will substitute data-driven algorithms with knowledge-infused algorithms, which do not need to learn through data-intensive training, a fact that may significantly reduce the associated energy consumption.

Second, building edge-cloud collaborative recommendations to empower sustainable green data centers. Real-time computing at the edge can leverage real-time information from users to provide better recommendations while reducing transmission consumption with the cloud and meeting green recommendations requirements. Edge recommendation systems can effectively capture user behavioral sequence modeling in real-time and adjust recommendation results to different interests of users. At the same time, with the power of edge computing, the entire personalized model can be fine-tuned and deployed locally on the users' telephones, thus achieving user privacy protection.

III. Conclusion

Research on sustainability has become increasingly important in recent years due to rising regulatory pressure and public awareness. Since recommendation systems can influence users' decisions, considering sustainability when making recommendations would be a promising approach to steer toward sustainable living.

In this paper, we outlined several challenges of achieving sustainable living through recommendation systems and then propose potential approaches to realize green recommendations in four scenarios, green products, green food, green travel, and green buildings. Finally, we proposed potential ways to make the recommendation algorithms more sustainable. We hope this paper could provide guidelines for eco-friendly recommendations.

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