Adapting Recommender Systems of E-Commerce Platforms to Deal with Cognitive Aging

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I have studied and reviewed the thesis written by Justyna Pawłowska-Bebel and my report is given below.

What are the research problems and objectives considered in the thesis, and have they been sufficiently clearly described by the author?

This thesis addresses the challenge of adapting e-commerce recommender systems to accommodate cognitive ageing. Recommender systems are sophisticated tools designed to aid users in decision-making by providing suggestions for items likely to interest them.

For older users, who may be more susceptible to the effects of cognitive ageing, influenced by heuristics and cognitive biases, this thesis delves into the hypothesis that age can significantly impact a customer's ability to make optimal choices within e-commerce systems. To validate this hypothesis, two experiments were conducted, explicitly stating that due to the cognitive constraints faced by older customers, their product choices in e-commerce tend to be less optimal compared to those made by younger customers.

The second hypothesis explored in this thesis pertains to the potential of recommendation algorithms trained on suboptimal data to exacerbate users' decision quality further. Additionally, a noteworthy contribution of this thesis lies in the identification of the issue of self-induced bias in recommender systems. This distinct form of data bias arises when users make suboptimal choices, consequently influencing the training of recommendation algorithms using data of suboptimal decisions. As a solution, the author proposes a simulation-based approach to measure the self-induced bias of a recommendation algorithm.

These hypotheses and four main objectives of investigation were sufficiently justified and motivated.

Does the thesis contain an appropriate analysis of state of the art (based on global scientific literature, current knowledge and applications in industry)? Does the analysis of related work demonstrate sufficient expertise of the author? Have the conclusions of the review of related work been sufficiently clearly stated?

Chapter 2 delves into the comprehensive theoretical background pertaining to various recommendation algorithms, including content-based, collaborative, and hybrid approaches.

Through a detailed examination, the chapter sheds light on the challenges confronted by recommender systems in their quest to provide accurate and relevant suggestions to users. Additionally, it offers a succinct overview of the psychological knowledge concerning processes associated with cognitive ageing, thereby establishing a crucial foundation for understanding the implications of age-related factors on decision-making within e-commerce systems. This part forms the basis for the research work depicted in later chapters by identifying the opportunity for a new investigation. For example, " the differences in cognitive capacity among individuals are yet to be addressed even in psychologically informed recommender systems".

The author's contribution to recommender system simulators is incorporating user bias and cognitive limitations into the user model. Hence, the final section of this chapter presents a meticulous review of the existing literature concerning bias and fairness in algorithms. By critically analysing prior research, the chapter explores the intricate nuances and ethical considerations surrounding the design and implementation of recommendation algorithms, particularly addressing potential biases and ensuring fairness in their outcomes. This comprehensive review provides valuable insights into the current state of knowledge in this domain and informs the subsequent investigation in this thesis.

Does the research described in the thesis use a correct scientific methodology?

The third chapter of this research rigorously examines the cognitive limitations arising from multi-attribute comparisons, and consequently, relevant literature in this domain is comprehensively analysed. Two psychological experiments involving human participants were conducted to investigate the impact of these cognitive limitations on decision-making in e-commerce. The primary objective of these experiments was to compare the decision-making abilities of older and younger users when making purchases in an e-commerce context. Specifically, the experiments aimed to shed light on how the cognitive constraints experienced by older consumers can influence their choices while utilizing a popular user interface function in e-commerce systems: product comparison. The results of both experiments confirmed the hypothesis that, due to the cognitive limitations of older customers, their choices tend to be less optimal than those made by younger customers. These findings provide valuable insights into the influence of age-related cognitive factors on decision-making within the e-commerce domain and underscore the significance of considering such limitations in designing and implementing user interfaces and recommendation algorithms for older consumers.

A meticulously formulated cognitive model of an agent engaged in purchasing decisions within an online shop is presented, drawing upon the results obtained from the experiments. This model encompasses three key elements: Agents, Items, and Recommender Systems. Its primary purpose is to facilitate an in-depth exploration of the advantages and limitations of various recommender system designs. The Agents within the model are constructed based on the decision-making characteristics of older consumers, as elucidated in psychological and cognitive research, along with the data collected in the experiments described in Chapter 3. By incorporating these insights, the model is a valuable tool for understanding users' decision-making processes within e-commerce. Furthermore, it considers the cognitive factors that come into play during the selection and comparison of products, providing a comprehensive framework for assessing the influence of age-related cognitive constraints on the efficacy of recommender systems.

The second hypothesis explored in this thesis posited that recommendation algorithms trained on suboptimal data may further exacerbate the decision quality of users. Various classical recommender systems were implemented to investigate the impact of cognitive limitations on decision quality comprehensively. The simulations conducted without the use of recommender systems served to discern the disparities between "young" and "old" agents and establish baseline results. Additionally, the magnitude of self-induced bias exhibited by older users of traditional recommender systems was meticulously measured and compared to that observed in customers who did not employ any recommendation system. However, the results from verifying this hypothesis inconclusive, warranting further investigation and analysis to ascertain its validity. This treatment allows for a comprehensive understanding of recommendation algorithms' implications and potential limitations in cognitive ageing and e-commerce decision-making.

To mitigate self-induced bias among older users, three novel algorithms were developed, drawing insights from theoretical research on cognitive ageing. The concept of self-induced bias in a recommendation algorithm pertains to the disparity in average utility between two distinct groups of agents: the biased class (older consumers) and the normal class (younger consumers) when the recommendation algorithm is utilized by all agents in the simulation. The efficacy of these newly devised algorithms was thoroughly evaluated within a simulated e-commerce environment.

The work described in the thesis with the right use of scientific methodology.

What are the original and innovative contributions of the author, and what is the position of these contributions compared to the state of the art? a. How do you evaluate the publication record of the candidate?

This thesis offers notable contributions to the current state of the art in the following areas:

Introduction of a novel research problem focused on recommendation systems trained on sub-optimal user choices, explicitly addressing the issue of self-induced bias, which represents a unique form of data bias. Additionally, a method is proposed to quantitatively measure self-induced bias using simulation, providing a robust approach to assess its impact.

Another contribution is the development of a sophisticated simulator for the e-commerce purchasing process, which is then integrated with a recommender system tailored to cater to clients with cognitive limitations. This simulator and its accompanying code are made available, offering a valuable resource for further research and experimentation.

Finally, the work proposed three innovative recommendation algorithms designed to mitigate self-induced bias and enhance the decision-making capabilities of customers with cognitive limitations. These algorithms demonstrate superior performance compared to optimally configured Collaborative Filtering and Content-based algorithms, showcasing their potential to significantly improve the user experience and effectiveness of e-commerce systems for individuals facing cognitive constraints.

By addressing these significant research problems and proposing effective solutions, this thesis contributes valuable insights and advancements to recommender systems.

The work in this thesis led to five publications thus adding knowledge to the field.

Did the author present his results correctly and convincingly? (Please evaluate the clarity, conciseness, correctness of the thesis or presented research articles).

There are five publications form this work, which was reviewed by experts and hence demonstrates the scientific rigour.

What are the weak and strong points of presented research results?

Overall, the thesis showcases the student's extensive knowledge in the field and valuable contributions to the topic. However, I believe certain sections could have been further refined in terms of articulation and clarity.

For instance, on page 26, scientific notations in the elaboration could have been presented more precisely and concisely to enhance the readers' comprehension and avoid potential ambiguity.

Similarly, on page 47, the task description for Experiment 2 could have been improved to provide more comprehensive and detailed information, aiding the readers' understanding, and facilitating replication of the experiment.

Overall, each chapter could have started with a clear introduction and ended the chapter with a summary section.

In addition, this thesis does not mention recent advances in Recommender techniques. Though this will not affect, the work reported, it would be interesting to discuss this in the limitations section.

While the thesis demonstrates the student's expertise and efforts, refining these specific sections would contribute to further enhancing the scientific rigour and overall clarity of the research work.

What is the contribution of the thesis to the discipline of information technology?

This thesis is dedicated to exploring the field of recommenders and their significant role in e-commerce scenarios, mainly focusing on the crucial aspect of cognitive issues, representing an important and timely problem in recommendation systems. The rigorous investigation presented in this research has resulted in the publication of five academic papers, effectively contributing to the existing body of knowledge in this domain.

The primary objective of this thesis is to delve into the intricate workings of recommenders within the context of e-commerce, with a keen emphasis on understanding and addressing the challenges posed by cognitive factors. By shedding light on the influence of cognitive

limitations on users' decision-making processes and the potential biases introduced by recommendation algorithms, this research aims to enhance the effectiveness and user experience of e-commerce platforms.

Through thoroughly analysing existing literature and implementing well-designed experiments, this thesis uncovers essential insights into the dynamics of recommenders and their impact on consumer choices. By expanding the understanding of the cognitive aspects of decision-making, the research contributes to developing more tailored and effective recommendation algorithms, with the goal of fostering improved decision quality for users, particularly those facing cognitive challenges.
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The culmination of this research endeavour has led to the publication of five academic papers, which serve as a testament to the quality and significance of the contributions made by this thesis to the field of recommendation systems. Each publication adds valuable knowledge and enriches the scholarly discourse surrounding the role of cognitive issues in e-commerce and the optimization of recommendation algorithms.

In conclusion, this thesis represents a comprehensive and in-depth exploration of recommenders in e-commerce, with a specific focus on cognitive considerations of older population. Through empirical investigations and scholarly contributions, this research advances our understanding of the challenges and opportunities in this domain and lays the groundwork for future advancements in recommendation systems.

Overall Recommendation

After reviewing the candidate's thesis and publication record, I support the acceptance of the thesis for the award of PhD.