Author: mgr Michał Bałchanowski
Supervisor: prof. dr hab. Urszula Boryczka

Doctoral Dissertation Abstract

Evolutionary rank aggregation in recommender systems

Many recommendation algorithms have been proposed in the literature, the purpose of which is to suggest a certain ordered list of items to the user. When evaluating recommender systems, we usually generate recommendations for individual users, then calculate the quality of the recommendations according to the chosen measure, and average the obtained results. However, it turns out that if we compare the suggested recommendations in the context of a particular user, the different algorithms generate recommendations that differ from one another and, thus, are of different quality. Since no algorithm generates high-quality recommendations for all users in the system, aggregation techniques, which have been used successfully in information retrieval systems, can improve the final quality of a recommendation. They make the fusion of rankings generated for a given user possible, which should improve the quality of recommendations.

The main objective of this dissertation is to develop an evolutionary rank aggregation (EAR) algorithm adapted for use in recommender systems that would be based on the DE algorithm. This algorithm will aggregate the rankings generated by the various recommendation algorithms and present a final ranking the user with that will be tailored to his personal preferences. This algorithm will be compared with other techniques used for aggregation.

The thesis statement is as follows: *The proposed algorithm of evolutionary rank aggregation improves the quality of the generated aggregation compared to the selected methods proposed in the literature*. The thesis was confirmed by the research presented in the individual chapters of the dissertation.

In addition, the dissertation consists of ten chapters and is divided into two main parts: theoretical (chapters: 2, 3, 4, 5, 6, 7) and experimental (chapters: 8, 9, 10). At the end of the dissertation, there is Appendix A and a glossary of symbols.

Chapter 2 provides essential information on recommender systems. It will present a formal definition of these systems and their basic classification. Additionally, the main challenges faced by developers will be discussed. An overview of selected recommendation

algorithms will also be presented. Moreover, Chapter 3 will describe sample measures that are used to assess the quality of the generated recommendations.

Chapter 4 will be devoted to metaheuristics, particularly the differential evolution algorithm. First, general information about metaheuristics, their historical background, and examples of applications will be described. Then a literature review will be presented, referring to their use in recommender systems. The Chapter will be concluded by the means of a description of the general scheme of the DE algorithm.

Chapter 5 will describe the idea of rank aggregation. This is a relatively new and under-researched approach, especially in recommender systems. This idea combines different sources of information, presented in the form of an ordered list of elements (rankings). It creates a new list based on them, which should be better than individual (base) lists.

Chapter 6 discusses a topic known in the literature as *learning to rank*. This technique is mainly derived from information retrieval systems. It involves using machine learning algorithms, usually based on supervised learning to create a ranking model whose task is to predict the ordering of items in a list. This approach can also be used in recommender systems, where once such a list of suggested items is created, it is presented to the active user in the form of recommendations.

Chapter 7 will be devoted to a description of the proposed algorithm. It will present different variants of the fitness function, which will then be tested in the experimental phase. The author's modification, which takes into account the rankings of other users in the aggregation process, will also be presented. The Chapter will also present the architecture of the proposed recommender system.

Chapter 8 will briefly analyze the *MovieLens 100k* dataset used in the experiments. In addition, it will discuss the details of tuning the parameters of the recommendation algorithms included in the aggregation. The research environment and methodology for conducting the experiments will also be presented.

Chapter 9 will be devoted entirely to experiments. Research on the impact of different fitness function variants on the created aggregation quality will be presented. In addition, the influence of other user’s rankings and randomly generated rankings on aggregation quality will be presented.

The last Chapter (10) will briefly summarize the entire dissertation and will present the conclusions. In this Chapter there will be a reference to the thesis of the dissertation, as well as information on the completion of secondary objectives. At the end of this Chapter, suggestions

regarding possible modifications to the proposed algorithm and directions for future research work will be presented.