Opponent's review of master thesis

Thesis name: Active Adaptive Algorithmic Quantification of Preferences
Author: Bc. Tereza Siváková
Supervisor: Ing. Miroslav Kárný, DrSc.
Thesis reviewer: Ing. Eliška Zugarová

The topic of the presented thesis is preference elicitation within a dynamic decision-making problem. The problem is described using the theory of Markov Decision Processes (MDP) and a framework derived from it, the Fully Probabilistic Design (FDP), which describes preferences of a decision-maker (user) probabilistically using an ideal behaviour distribution instead of a utility function. The goal of this thesis is to propose a solution that incorporates the user's feedback in order to obtain a better understanding of their preferences and achieve more satisfactory results.

The thesis starts with an extensive introduction presenting the problem and describing the approach of adding an extra layer of a "meta-task" to the decision-making process. Based on the user's feedback it provides the base (original) layer with additional information needed to propose an optimal decision policy. A schematic explanation of the two layers is provided for better understanding. A brief overview of the state-of-the-art is also presented.

Introduction is followed by a chapter that contains theoretical background, mainly definitions of the MDP, the FPD and Bayesian learning that is used to estimate an unknown system model.

Next chapter is dedicated to introducing the preference elicitation into the FPD framework. Several theorems leading to finding an optimal solution are proposed and proved. Overall, the proofs are fairly rigorous, even though in some cases it would be profitable to describe the steps in greater detail to facilitate understanding. In the last two proofs, a mathematical theory is used (Fredholm integral equation and its solution) that is not reminded in the first chapter, where some much more basic definitions are established, e.g. chain rule, p-norm. The chapter is concluded with an algorithm that finds the optimal solution.

Chapter 3 explains the motivation behind the "meta-task" and reveals how it is formulated and solved in the same way as the main task. Preference elicitation parameters that need to be set to find the primal solution are obtained as the "meta-solution", which is found using the user's reaction to the outcomes of the decision-making.

Chapter 4 verifies the proposed solution via a set of simulated experiments. The experiments are well designed to show the contribution of the "meta-layer" approach. Results are evaluated in an adequate manner in the form of a commentary, graphs and a summarising comparison table. What is missing is a clear description of how the experiments were conducted. It is mentioned only later in the chapter that real users were asked to give feedback. What were the instructions given to them is not reported. It is also not explicitly indicated how many steps were in one experiment, if the same system model was used in all experiments, or what value of parameter ν was chosen in Experiments 2 and 3.

Finally, conclusion summarises the main contribution of the thesis, results of the experiments and discusses possible future improvements.

The submitted work fulfils all the requirements listed in the thesis assignment. The text is logically well arranged and structured. It is written in decent English, some grammatical and syntactical mistakes can be found that make understanding the text a bit difficult. The main definitions and theorems are appropriately declared. The figures, schemes, and tables are shown properly and are clear and demonstrative. All resources are well cited throughout the thesis. Several state-of-the-art sources are mentioned, however, a more in-depth summary of some more recent work would be appreciated. A few small mistakes and inconsistencies can be found in the text (for example naming s^j as the preferred state in (1.7) or parameter $\nu > 1$ reaching the value 1 in the experimental part).

Overall, I judge the presented thesis as a work of high quality with an interesting subject and approach. The student demonstrated the ability to formulate a problem mathematically, propose an appropriate solution, implement and verify it. In my opinion, the language could be improved to permit faster understanding to the reader. Several parts of the text would benefit from a more detailed or clear description of the subject and there are some minor mistakes in the text.

I propose the classification grade **B - very good**.

I have the following questions:

1. How is the dimensionality or complexity of the problem affected when the sets of preferred actions and states contain more than one element?
2. How much more computationally complex does the solution become when the “meta-layer“ is added?
3. The system model is learnt using Bayesian learning. It takes some time to obtain a reasonable approximation of the model. In your opinion, did the incomplete knowledge have any effect on the results of the simulated experiments? Would the results be any different if the model was known?

Date: 19.1.2022 Ing. Eliška Zugarová