

# Supervisor's Review on the Doctoral Thesis

Author: Mgr. Matej Moravčík

Title: Bridging the Gap: Towards Unified Approach to Perfect and Imperfect Information Games

## Contents of the thesis

The thesis begins with an introduction to games, including both perfect and imperfect information games and giving some basics about extensive form games and the necessary notion.

The following chapters are devoted to the particular Matej's papers. They deal with perfect and mainly imperfect information games. The important representant of the imperfect information games is poker, but the proposed algorithms have a more general scope. The focus of the chapters is on the counterfactual regret minimization (incl. its variants and variance reduction techniques), soundness of the algorithms, refining subgames, and developing algorithms for no-limit Texas Hold'em poker (DeepStack) and for a general class of games (Player of Games).

Matej carefully points out his own contribution in the published papers and in the thesis. The thesis ends with concluding remarks and addressing directions of possible future research. I have also to mention a large collection of appendices at the very end of the thesis.

## Scientific contribution

In the aforementioned area, Matej significantly contributed to the theory and (mainly) to the algorithm development. The results were published in the best journals and conference proceedings and obtained great attention, not only in the AI community. Even more, Matej is a co-founder of the startup EquiLibre Technologies, which aims to transfer the results to practice, in particular to algorithmic trading.

Theoretical achievements include, e.g., the following:

- Bounding a priori the support size of optimal stochastic strategies, which was derived based on the theory of linear programming.
- Developing of the concept of soundness; it is a concept suitable for online models, in contrast to the traditional (Nash) equilibria defined for offline settings.

From the algorithmic perspective, Matej's contributions are amazing. Let me mention just a sample of them:

- Refining subgames to reduce exploitability in large imperfect information games. To this end, a novel concept of subgame margin was introduced. I was particularly captivated by the linear programming formulation and its employment.

- Proposing a method AIVAT to considerably reduce the variance in evaluation of poker competition and thus to reduce the number of matches to play. This technique is provably unbiased.
- Together with Martin Schmid, they were the main authors of DeepStack, the first program that beat professional human players in no-limit Texas hold'em poker. This was a milestone result, following the great events when AI beat humans in the games of chess and Go. It was a basis for a paper published in Science, being highlighted in the journal volume front cover.
- Developing Player of Games, which is a general method for solving perfect and imperfect information games. It synthesizes state-of-the-art techniques, while utilizing a minimal prior information about the game in order to work in a general environment. It performs well in many games, including chess, go, poker or Scotland Yard.

## Summary

The scientific results of Matej are extraordinary. He not only published in top journals and proceedings (including Science and A\* ranked conferences), but the achievement of the poker algorithm DeepStack was a true milestone in AI.

Therefore I strongly recommend to **accept** the thesis. I also believe the thesis can be nominated for a suitable prize.

In Prague, November 23, 2023

prof. Mgr. Milan Hladík, Ph.D.

---

Charles University, Faculty of Mathematics and Physics,  
Department of Applied Mathematics,  
Malostranské nám. 25, 118 00 Prague, Czech Republic,  
e-mail: [hladik@kam.mff.cuni.cz](mailto:hladik@kam.mff.cuni.cz).