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RE: Referee report for the thesis of M. Moravčík titled "Bridging the Gap: Towards Unified Approach to Perfect and Imperfect Information Games"

Dear Dean doc. RNDr. Mirko Rokyta, CSc.:

Thank you for the opportunity to review this dissertation, and to comment on it by way of this report. Having read this contribution and its appendices / attachments / supplementary material in detail, **it is clear to me that this thesis proves the author's ability to conduct and disseminate creative scientific work**. This dissertation comprises a substantial number of novel scientific results that have been disseminated in top conferences and journals relevant to its fields of impact and application (for example, AAAI, AAMAS, JAIR, and, importantly **two papers in the *Science* journal family** where this dissertation's author was first or second author). I note that, in the time since this dissertation was finalized, Chapter 10 on the Player of Games was published in its final form in *Science Advances* with Mr. Moravčík as second and substantially contributing author. In all these papers, Mr. Moravčík is recorded as having meaningfully contributed to ideation, theory, algorithm design, experimental design and execution, evaluation and/or analysis. This is well documented in the thesis chapters, and also, during my further review, in contributions sections of the incorporated publications.

This impressive roster of publications would alone be a strong indication that the results contained in this thesis can be referred to as new and important scientific results. As substantiated by the dissertation, this work does indeed advance both the theory and the algorithms of multiagent strategic interactions in both perfect and imperfect information games. This includes updated or novel proofs, exposing new relationships between factors of games/environments and the surrounding theory or its application, and estimating or evaluation methods for the domain of imperfect information games with large possible branching factors. Critically, this thesis contains world-class innovation in *both* the DeepStack and the Player of Games (now termed, "Student of Games" in its *Science Advances* publication) agents for poker and other perfect- or imperfect- information settings. By the Ph.D. standards of my own University and our field in general, **there is no question that the scientific results in this thesis are new, valuable, and of noteworthy international significance.**

To directly quote the thesis, this work introduces a "universal algorithm that can master both perfect and imperfect information games starting from scratch." **This is a remarkable accomplishment, and one that is very important** for not just the field of games and game theory, but for the broader community of artificial intelligence, machine learning, and automation. Coupled with DeepStack innovations and the supporting theoretical, algorithmic, and evaluative work in this dissertation, the "[t]echniques discussed in this thesis help to bridge the gap between perfect and imperfect information." Further, they help bridge the gap between game theory and reinforcement learning in new and important ways, making the insights from these two fields deployable and accessible to each other. While I would have liked to have seen a greater degree of rigour in the typography of the thesis, and a greater level of description of key background ideas that would have helped future non-specialist readers better engage with the work (e.g., readers in neighbouring fields), I found no major barriers to the future interpretation and use of the contained work. As such, I can confidently state that in sum total the work in **this thesis unlocks a range of applications and further studies in neighboring areas** such as robotics, industrial automation, human-machine interaction, sociology and governance, business/economics, public safety, and the entertainment industry. I would welcome Mr. Moravčík's comments as to the nature of some of these potential extensions, and any perceived impact not included in the concluding claims section of the document.

The work in this thesis is a solid building block for future research and development. **In my opinion, the degree of PhD should be awarded based on the contents and impact of this thesis.**

It was a pleasure to review this thesis. Thank you again for inviting this report. Please do not hesitate to contact me if you require any further clarifications or detail regarding my assessment of this thesis or the way it firmly supports its author's ability to conduct novel, meaningful, and creative scientific research.

Sincerely,

Patrick M. Pilarski, Ph.D.

Canada CIFAR AI Chair (Amii) &
Past Canada Research Chair in Machine Intelligence for Rehabilitation,
Associate Professor, Department of Medicine, University of Alberta

Fellow and Board of Directors,
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