

# Report on the outcomes of a Short-Term Scientific Mission<sup>1</sup>

Action number: CA22145

Grantee name: Jakub Kowalski

## Details of the STSM

Title: Extending Monte Carlo Tree Search: Proofs and Explainability.

Start and end date: 01/03/2025 to 29/05/2025

## Description of the work carried out during the STSM

Description of the activities carried out during the STSM. Any deviations from the initial working plan shall also be described in this section.

*(max. 500 words)*

Activities carried out during the STSM were generally aligned with the initial working plan.

The PN-MCTS algorithm was generalized to properly handle games with more than two players. Handling arbitrarily many outcomes by using multiple PN trees was implemented but proven computationally inefficient; therefore, it was solved by hybridizing with Score bounded MCTS enhancement.

The preliminary work towards the explainability of MCTS enhancements has been done. In particular, we developed a Ludii implementation of Explainable MCTS that presents to the user reasoning regarding the chosen in-game move in a template-based, human-friendly format. A wider range of enhancements than initially planned have been considered, including: MAST, RAVE, NST, PNS, and Score bounded MCTS.

Both objectives resulted in publication-ready preprints already submitted to AI conferences.

## Description of the STSM main achievements and planned follow-up activities

<sup>1</sup> This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the GH for payment of the Grant.

Description and assessment of whether the STSM achieved its planned goals and expected outcomes, including specific contribution to Action objective and deliverables, or publications resulting from the STSM. Agreed plans for future follow-up collaborations shall also be described in this section.

*(max. 500 words)*

STSM fully achieved the planned goals and expected outcomes.

The main results of the STSM are, as planned, two publications available on ArXiv and submitted to AI conferences:

- Generalized Proof-Number Monte-Carlo Tree Search (<https://arxiv.org/abs/2506.13249>, Jakub Kowalski, Dennis J. N. J. Soemers, Szymon Kosakowski, Mark H. M. Winands)
- Towards Explaining Monte-Carlo Tree Search by Using Its Enhancements (<https://arxiv.org/abs/2506.13223>, Jakub Kowalski, Mark H. M. Winands, Maksymilian Wiśniewski, Stanisław Reda, Anna Wilbik)

The second publication contributes to the task T6 from the Action MoU, regarding AI explainability.

The implementation of the Generalized PN-MCTS algorithm was prepared accordingly to the Ludii AI templates, and will be proposed as a contribution to be included in the system.

During the stay, I gave a talk at the Host Institution for the DACS Games & AI group, entitled "Competitive (Game) AI".

Plans for follow-up collaboration have been established, including further improvements and tests over PN-MCTS, as well as a larger project in the early stage of planning for the Explainable Search domain.