

Report on the outcomes of a Short-Term Scientific Mission¹

Action number:

Grantee name:

Details of the STSM

Title: Learning for Automated Theorem Proving Based on Proof Structures in the Presence of a Large Proof Library

Start and end date: 30/03/2024 to 05/04/2024

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)

During this STSM, I visited Christoph Wernhard, researcher at Potsdam University. Our previous joint work was related to learning to identify useful lemmas to aid automated theorem proving. We met with the intention to discuss and lay the groundwork of a new project in continuation of the previous one. We looked into MetaMath, a representation framework for formal maths. Metamath has a large (over 40000) corpus of formal proofs and we focused on understanding how these proofs are structured and how they could be structured better. The primary mechanism for proof structuring is the introduction of auxiliary lemmas, avoiding repetition, enhancing interpretability and making the overall size of proofs manageable for a human mind.

We discussed different ways of representing proofs and lemmas, with an emphasis on how much compression they provide and how amenable they are to structure enumeration - structure enumeration is a powerful mechanism for automated proof search and my host, Christoph has done significant work on the topic. We found that most of the results and techniques that were previously developed for problems of Condensed Detachment in the TPTP proof library are directly applicable to proofs in MetaMath.

¹This 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 of the STSM main achievements and planned follow-up activities

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)

We implemented a fair amount of Prolog code that extracts and processes proofs from the core set.mm library of MetaMath into Prolog format that we will work with later. We discussed several ways of automatically/algorithmically structuring proofs. In particular, we identified the TreeRePair algorithm ([10.1109/DCC.2011.42](#)) as a simple and potentially useful baseline method for proof structuring. During the STSM, we implemented a Prolog version of this method and started some initial analysis of the extracted lemmas. In this first phase, we intend to do some comparative analysis of real lemmas in the MetaMath database and those extracted by simple heuristic methods like TreeRePair and hopefully come up with more informed ways of identifying lemmas. In the longer term, we are also interested in using machine learning directly to parameterise/control a TreeRePair like algorithm, trained to reconstruct human lemmatization.

Overall, I find the STSM very successful and productive. It served the role of turning vague ideas into a concrete project. Such meetings are extremely important for researchers working together remotely. We expect to have some interesting findings by the beginning of May 2024 and submit an abstract to the AITP2024 conference (<http://aitp-conference.org/2024/>)