Report on the outcomes of a Short-Term Scientific Mission[1]

Action number: CA20111

Grantee name: Karol Pąk

Details of the STSM

Title: Automated Translation of Mizar Declarative Proof

Start and end date: 17/04/2023 to 06/05/223

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)

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The main result of the project has been the development of a prototype of syntactic-semantic export of the Mizar scripts. Our previous export combined two representation of the proofs, syntactic (`*.wsx`) and semantic (`*.xml`), which required handling multiple cases. To avoid the limitations of this solution, in the case of reasoning using Mizar system structures, we have rebuilt our export to be based on a new layer (still under development in the Mizar system) (`*.mizx`), where the information stored in the syntactic and semantic layers is merged directly by the Mizar system and not by our external tool. This solution is particularly useful due to easier access to information on structural Mizar types, which was not previously covered by our automatic export.

We also discussed the usefulness of information that is more easily accessible in the new format. We tested the usefulness of this information in the context of premis-selection in estimating the amount of background information that is used implicitly in justifying the various steps. Experience with ATP support, developed by Josef Urban in step justification, has shown that the proposed list of theorems, even if sufficient to justify a step, generally contains theorems that are not available in the Mizar environment. Using the new layer, we developed a tool that rebuilds the environment in the Mizar proof script by adding the necessary list of constructions, notations and definitions to import the indicated list of theorems. We examined information contained in this layer to extract a list of terms and predicates,

[1] 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.

substituted in the schema Mizar, a second-order theorem. However, we are able to provide only a very simple export so far.

On the Isabelle system side first, we tested the possibility of using metis tactics instead of auto tactics used before. In our exports, most of the reasoning is done at the FOL level. However, mimicking the Mizar system, we implemented in Isabelle/Mizar the obligation that cavantifiers are quantifiers defined for non-empty types. In the case of auto tactics, we already have a method to eliminate most assumptions about non-empty types, added using simproc_setup.

We have not been able to implement such a method that would adequately prepare the goal for metis tactics. We implemented a prototype of the Mizar environ in the Isabelle/Mizar, which allows selective import of background information into an article. This solution enabled us to significantly speed up the verification of our formalization.

Finally, we focused on properties of predicates and terms that are implicitly used in justifications by the Mizar system. We planned to extract the locations where such properties are used from the new Mizar layer. Instead we implemented an analogous mechanism in Isabelle/Mizar. We focused our efforts on building mechanisms at the level of Isabelle/ML and Eisbach that collect such properties and add them for a considered goal. We have implemented an analogous solution for Mizar requirements.

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.

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The main result the application obtained were:

- Implementation of a new layer of the Mizar system as the basis of our exports.
- Coverage of structural Mizar types by our automatic export.
- Develop a tool that automatically rebuilds the proof script environment according to the new list of theorems to be accessed in the environment.
- Collect information about the properties of predicates and functors, analogous to the Mizar system, and use this information to justify each step in Isabelle/Mizar.
- Developed a prototype of the Mizar system environment in Isabelle/Mizar, which speeds up the verification of scripts.

Currently, Dr Karol Pąk, an applicant, and Dr Cezary Kaliszyk, representing the host institution, are working on the publication of the results obtained during the STSM visit. We describe the results obtained by implementing the prototype environment implemented in Isabelle/Mizar, which mimics the Mizar system environment.

The STSM enabled the next stage of collaboration between the applicant and the host institution, mainly with Dr Cezary Kliszyk, who has implemented further solutions that allow declarative reasoning in the Isabelle system in a style close to Mizar, where an increasing number of MML theorems are available.