Short-Term Scientific Mission Grant
- APPLICATION FORM[1] -

Action number: CA20111

Applicant name:

Details of the STSM

Title: Informalization and Autoformalization with Dedukti and GF

Start and end date: 9 to 16 April 2025

Detail of the cost in EUROS:

- Transport (upload screen capture): 428

- Hotel/day (upload screen capture): 88

- Food/day: 72

TOTAL: 1548

Goals of the STSM

Purpose and summary of the STSM.

(max.200 word)

The purpose of this STSM is to improve the interoperability of Dedukti and GF (Grammatical Framework) in translating between formal and informal mathematics, and scale up its applicability. This is done in the context of the project Informath, whose goal is to develop a system that translates between several formal and informal languages. In order to maximize scalability and make the best use of resources, Informath uses interlinguas: Dedukti for formal systems and GF for natural languages. Thus the main part of translation takes place between Dedukti and a GF abstract syntax that targets several natural languages.

A first version of Informath already provides a two-way translation between Dedukti (with mappings to Agda, Coq, and Lean) and a controlled natural language (CNL) targeting English, French, and Swedish. The system has been tested on a couple of thousand formal statements provided by Dedukti. During the STSM, we want to (1) develop a better understanding of how Dedukti works as an interlingua of formal systems and (2) build a more comprehensive corpus of formalized material for evaluating the system and also to enable machine learning autoformalization experiments with synthetic training data.

[1] This form is part of the application for a grant to visit a host organisation located in a different country than the country of affiliation. It is submitted to the COST Action MC via e-COST. The Grant Awarding Coordinator coordinates the evaluation on behalf of the Action MC and informs the Grant Holder of the result of the evaluation for issuing the Grant Letter.

Working Plan

Description of the work to be carried out by the applicant.

(max.500 word)

The project Informath aims to build a comprehensive system for translating between formal and informal mathematics, including verbalization of Coq (Coscoy, Kahn and Théry 1995), Isabelle-Isar (Wenzel 1999), Agda-Alfa (Hallgren and Ranta 2000), ForTheL (Paskevich 2007), Naproche (Cramer and Koepke 2009), and MathNat (Humayoun and Raffalli 2012). Their purpose has been to provide a gentle interface for users of proof systems, as well as a tool for documenting formal proofs automatically.

A common feature of earlier systems is that they use a controlled natural language (CNL). A CNL is defined in a similar way as formal languages,but looking like natural language (usually English) and readable without a knowledge of the formal language of the system. While being able to render formal content in English, a CNL does not support parsing normal mathematical English, because it only covers a fragment of it.

The Informath project aims to scale up such translations to a new level. Its core is still a CNL, but this CNL is continuously extended to cover more language, guided by existing mathematical texts. In this work, the use of GF (Grammatical Framework) and its Resource Grammar Library (RGL) plays a crucial role. With the RGL, complex linguistic structures can be accessed via a high-level API, which is moreover interlingual: the same RGL-based code can be used for retargeting the translation to many languages (currently English, French, and Swedish). On the formal side, Dedukti can likewise be used for targeting many formal systems (in Informath currently Agda, Coq, and Lean).

Many recent developments on translating between formal and informal mathematics use machine learning (neural networks and large language models) rather than CNLs. Their problem is the lack of training data - of large enough sets of formal-informal example pairs. Informalization has turned out to be a good way to create such pairs as synthetic data (Jiang, Li and Jamnik 2023). One expected outcome of Informath is better and more variable synthetic data than in earlier approaches, which use either simple CNLs or noisy data produced by Large Language Models (LLMs).

During the STSM, we plan to improve the usage of Dedukti in the Informath project and thereby extend the scope of translations. This includes

- translations between Dedukti and other formal systems X, in particular in the Dedukti to X direction, which is less developed and (because of the wider expressivity of Dedukti) only partial
- usage of libraries available in Dedukti format to generate more examples of formal-informal pairs
- mechanisms for hiding and restoring information: while Dedukti is completely explicit, other formal systems have various ways to drop and reconstruct parts of the code, which is analogous, but not equal, to the way in which natural language works

Expected outputs and contribution to the Action MoU objectives and deliverables.

Main expected results and their contribution to the progress towards the Action objectives (https://europroofnet.github.io/objectives/) and deliverables (https://europroofnet.github.io/deliverables/).

Working groups to which this mission contributes: WG1, WG5

(max.500 words)

The main expected outputs of the STSM are:

- improved usage of Dedukti and connected formal systems in Informath
- extended corpus and lexicon of mathematics based on libraries available through Dedukti

The results will be continuously released via Informath's github repository, https://github.com/aarneranta/informath

The work will address the following Action objectives:

Research Coordination Objectives

6 Develop the use of artificial intelligence and machine learning techniques on proofs.
- this will happen via improved methods to generate synthetic language data from math libraries and the actual dataset that will be built to demonstrate them

8 Develop the use of natural or controlled languages in proof systems.
- this is the main objective of the Informath project

Capacity building objectives

1 Bring together members of the different communities working on proofs in Europe.
- The STSM itself brings together Chalmers/Gothenburg (Agda, GF) and LFM INRIA Saclay (Dedukti). Other sites collaborating with Informath include Bonn, Erlangen-Nürnbeg, Manchester, and Prague.

4 Ease access to formal verification techniques in education and other areas of science.
- Accessibility via natural language can help students and non-programmer mathematicians.

6 Transfer knowledge in terms of expertise, scientific tools and human resources across the different disciplines and between academia and industry.
- The Informath project connects the formal proof community with the linguistic community.
- The project uses prior experience from an industrial project where a full-scale natural language interface was built for the specification language Z, showing that GF can scale up to such tasks (Altran UK and Digital Grammars 2018, proprietary software)