2019-01219 - Graph matching: theory and SAT implementation (research internship)

Level of qualifications required: Bachelor's degree or equivalent

Fonction: Internship Research

About the research centre or Inria department

Located at the heart of the main national research and higher education cluster, member of the Université Paris Saclay, a major actor in the French Investments for the Future Programme (Idex, LabEx, IRT, Equipex) and partner of the main establishments present on the plateau, the centre is particularly active in three major areas: data and knowledge; safety, security and reliability; modelling, simulation and optimisation (with priority given to energy).

The 450 researchers and engineers from Inria and its partners who work in the research centre’s 31 teams, the 100 research support staff members, the high-level equipment at their disposal (image walls, high-performance computing clusters, sensor networks), and the privileged relationships with prestigious industrial partners, all make Inria Saclay Île-de-France a key research centre in the local landscape and one that is oriented towards Europe and the world.

Context

This research internship is offered at Inria Saclay IdF (https://www.inria.fr/en/centre/saclay) in the LIFEWARE project-team (http://lifeware.inria.fr). This team works in computational systems biology and develops the Biochemical Abstract Machine (BIOCHAM http://lifeware.inria.fr/biocham4) software for modeling, analyzing and now synthesizing biochemical reaction networks (CRNs) using methods from fundamental computer science and mathematics. The software developments are expected to be integrated in BIOCHAM.

The internship will be supervised by François Fages and Sylvain Soliman.

Assignment

Graph matching problems concern the detection of similarities between two graphs G and H. The exact graph matching problem is the problem of existence of a graph isomorphism between G and H. The subgraph isomorphism problem (SISO), i.e. the existence of a graph isomorphism between a subgraph of G and H, is an NP-complete problem. SISO provide a standard notion of graph motif and are widely used in pattern recognition in various domains. In the context of systems biology, the question of detecting model reduction relationships between biochemical reaction networks (CRN bipartite directed graphs) in large model repositories, led us to the notion of subgraph epimorphism (SEPI), i.e. subgraph morphism surjective on vertices and edges. The existence of a SEPI from G to H is indeed equivalent to the existence of a sequence of deletions or mergings of vertices in G that lead to a graph isomorphic to H, which, in the context of CRNs, are basic operations for simplifying a model by neglecting or merging some species or reactions. We have shown that the SEPI problem is NP-complete but that its encoding as a constraint satisfaction problem, and the use of constraint programming or SAT solvers, provide a sufficiently efficient solution in practice with few exceptions.

The goal of this research internship is to develop this approach in mainly two directions:

- investigate the theory of a refinement of SEPIs in which only adjacent vertices can be merged (at distance two in the bipartite graph of a CRN), and differences with graph minors,
- investigate the theory of minimal SEPI upper bounds, and maximal SEPI lower bounds, with the restrictions above.

To this end, an implementation will be made by refining the existing implementatin using a SAT solver, and integrated in BIOCHAM for evaluation on large scale in BioModels.

Main activities

Our previous work on this subject is described in


The theoretical work will consist in investigating similar properties for the notion of restricted SEPIs.

The implementation work using SAT solvers will be expected to be integrated in BIOCHAM and evaluated on the repository of models BioModels as initially done in


Skills

This subject requires a pronounced taste for graph theory, and common and basic knowledge in algorithmics and programming.

Specific knowledge about SAT solvers, constraint programming, Prolog, or systems biology will be a plus.
Benefits package
- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Flexible working hours
- Sports facilities

Remuneration
500 euros/month + living compensation for foreigners

General Information
- Theme/Domain: Algorithmics, Computer Algebra and Cryptology
- Town/city: PALAISEAU
- Inria Center: CRI Saclay - Île-de-France
- Starting date: 2019-04-01
- Duration of contract: 6 months
- Deadline to apply: 2019-03-31

Contacts
- Inria Team: LIFEWARE
- Recruiter: Fages François / francois.fages@inria.fr

About Inria
Inria, the French national research institute for the digital sciences, promotes scientific excellence and technology transfer to maximise its impact. It employs 2,400 people. Its 200 agile project teams, generally with academic partners, involve more than 3,000 scientists in meeting the challenges of computer science and mathematics, often at the interface of other disciplines. Inria works with many companies and has assisted in the creation of over 160 startups. It strives to meet the challenges of the digital transformation of science, society and the economy.

The keys to success
We are seeking a highly talented and motivated candidate not afraid by crossing disciplinary frontiers.

Instruction to apply
Send an e-mail with CV + cover letter to Mr François Fages: francois.fages@inria.fr

Defence Security:
This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST). Authorization to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

Recruitment Policy:
As part of its diversity policy, all Inria positions are accessible to people with disabilities.

Warning: you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.