Optimization of fixed-point formats in numerical programs

Leo Liberti

LIX, École Polytechnique, 91128 Palaiseau, France

leoliberti@gmail.com

December 19, 2007

A post-doctoral fellowship of 1 year is going to be opened at LIX (Laboratoire d'Informatique), a department of Ecole Polytechnique in Palaiseau, near Paris (France), linked with a national project called EDONA, subsidised by the french ministry of industry.

Research topic. Embedded systems, such as engine controllers, fly-by-wire or X-by-wire computers, airbag controllers to mention but a few, rely on numerical algorithms. However, the embedded implementation can only use finite precision arithmetic (as opposed to floating point), and hence exhibits imprecision errors with respect to the true real number computation. In general, these numerical algorithms are tested according to floating point specifications, hence their reliability in finite precision arithmetic is not clearly ascertained.

The overall goal of this project is to optimize the size (number of digits before and after the comma) of fixed point (i.e. finite precision) variables involved in the numerical algorithm, with the objective to be no less precise than the floating point computation, with respect to the real number computation.

The technique that we put forward in this project is the static analysis of the code by abstract interpretation [1], that is, the automatic determination of computer program properties, by over-approximations, from the source code and without any executions. We have already applied it to the determination of good bounds for the floating point, fixed point (in a given format) and real values of program variables, together with good bounds for the imprecision error [2], which is implemented in the tool FLUCTUAT.

The aim of this postdoc is to develop a method and tool for optimizing the number of bits required to make a given calculation in fixed point format, according to several objectives; one of which is, as specified above, that of being no less precise than the floating point computation (our current line of work includes modelling a similar problem by means of a mathematical programming formulation). Ultimately, we want to develop a black-box/grey-box optimizer, linked with the floating-point semantics and a very simple fixed-point semantics implemented in FLUCTUAT.

Further information can be found at the following web page: `http://www.di.ens.fr/~cousot/COUSOTPapers.shtml` (static analysis)

General information. This postdoc is funded partially by École Polytechnique and partially by the EDONA project (a sub-project of the Île-de-France competitivity pole "System@tic"). The candidate will work within the MeASI (Modélisation et Analyse de Systèmes en Interaction) research group, and in particular with Leo Liberti, Daniel Krob, Sylvie Putot and Eric Goubault. The successful candidate should be familiar mainly with static analysis of code, model checking, semantics and verification, and secondarily with modelling, optimization and algorithmics. Required technical skills: C/C++, verification codes, and optionally AMPL/CPLEX. Since we know that it is extremely unlikely to find the perfect match to *all* these requirements, candidates with subsets of the listed skills are encouraged to apply — but must be prepared to invest some time in acquiring the missing knowledge if retained. Candidates with some industrial experience are also encouraged to apply.

The postdoctoral position, physically located at LIX, École Polytechnique, is paid around 2000e/month after social charges but before income tax (so the net amount should be between 1700 and 1800 euros

/ month, which is enough to live decently in Paris without a family to provide for). The contract can be started as early as possible after mutual agreement. The position will be available until filled, but to ensure a full consideration, please submit the following application material by 15th January 2008, in either English (preferred) or French.

Application procedure. Applications must be made in electronic form. Zip all your PDF files specified below (that's **ZIP**, not RAR or any other compressed format) into a single file called *surname*`.zip` and send it to `leoliberti@gmail.com`.

1. A full CV: education, positions filled, research interests, involvement in funded projects, teaching experience, academic visits and seminars, programming and technical skills, spoken/written languages, publication list (refereed journals, refereed conference papers, theses, other published material, technical reports, patents, software documentation). Name this file *surname*`-cv.pdf`.
2. A covering letter specifying why you think you would be a good match for the position. If you are missing some of the required skills / knowledge, but you still think you would be a good candidate, you can explain why here, and what you plan to do to acquire the missing skills. Name this file *surname*`-covering.pdf`.
3. A copy of the most relevant papers you have published (papers "accepted for publication" count as published, submitted papers count as technical reports). Name this file *surname*`-paper-`i`.pdf`, where i ranges over the size of your paper production.
4. A copy of your Ph.D. thesis, and if appropriate also of your M.Sc. thesis. Name these files *surname*`-phd.pdf` and *surname*`-msc.pdf`.

WARNING: All material must be submitted in PDF format. Other formats (including MS Office) will not be considered.

References

[1] P. Cousot and R. Cousot. Abstract interpretation: a unified lattice model for static analysis of programs by construction of approximations of fixed points. *Principles of Programming Languages*, 4:238–252, 1977.

[2] Eric Goubault and Sylvie Putot. Static analysis of numerical algorithms. In *Proceedings of SAS*, pages 18–34, 2006.