Editorial: Track Reliable Computations and their Applications

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1 Objectives of the track

Many numerical computations, be they solutions to systems of differential equations or optimization problems coming from applied areas like protein folding, do not provide us with guaranteed computation results. In many situations, we have numerical solutions, we may even have a theorem guaranteeing that, eventually, this numerical solution tends to the actual precise one, but the algorithm itself does not provide us with guaranteed bounds on the difference between the numerical approximate solution and the desired actual one. Therefore, in some practical situations, numerical solutions are much farther from the actual (unknown) precise solutions than the users assume.

It is therefore desirable to develop a methodology that would provide algorithms with automatic result verification, i.e., with automatically generated upper bound on the difference between the actual and the numerical solution. In other words, we need computation techniques that produce reliable (guaranteed) results.

This problem was recognized already in the 1950s. The corresponding techniques, largely developed by Ramon E. Moore, were later applied in guaranteeing trajectories of spaceflights and in other practical problems where deviations from the target are of critical importance. The main idea behind these techniques is that at any intermediate step of the computations, instead of the exact number, we keep an interval of possible values. For inputs (that usually come from measurements), we have an interval because measurements are never 100% accurate; if the manufacturer of the measuring instrument guarantees that the measurement error is Δ or smaller, then the measuring result $\widetilde{x}$ means that the actual value is in the interval $[\widetilde{x} - \Delta, \widetilde{x} + \Delta]$. At each elementary computational step, we apply interval arithmetic to the corresponding intervals and produce the interval for the result; e.g., $[a, b] + [c, d]$ leads to $[a + c, b + d]$.

Of course, this “straightforward interval computation", that does not take dependence between intermediate results into consideration, does not always lead to efficient estimates. However, in the last 40+ years, efficient interval computations methods have been developed based on this original idea. There are a lot of interesting applications of interval computations, there is a lot of potential, but there are still a lot of open problems, situations where new techniques are needed.

One such technique that has also been used to provide guaranteed bounds is the technique of constraint propagation. This technique originated in logical AI problems, and it has been lately successfully applied to numerical problems, often in conjunction with interval methods.

For example, one of the latest textbooks on interval computations, by Jaulin et al., contains robot-related practical examples of combining these two techniques. This combination has started, it is the object of interest by many researchers, it has already led to interesting and efficient packages like Numerica, but there is still a lot of room for potential improvement.

Our track, with an emphasis on such a combination, brings together not only algorithm developers but also practitioners whose practical needs will help guide researchers in the proper directions.

2 Contributed papers

We received 14 article submissions, from Bulgaria, China, France, Russia, Turkey, and the USA. These papers were reviewed by Lucas Bordeaux (Microsoft), Olac Fuentes (University of Texas at El Paso – UTEP, USA), Frederic Goualard (Laboratoire d'Informatique de Nantes – LINA, University of Nantes, France), Chenyi Hu (University of Central Arkansas, Conway, USA), Luc Jaulin (Ecole Nationale Supérieure des Ingénieurs des Études et Techniques d'Armement – ENSIETA, Brest, France), Yahia Lebbah (University of Nice – Sophia-Antipolis, France), Claude Michel (University of Nice – Sophia-Antipolis, France), François Modave (UTEP, El Paso, Texas, USA), Linet Ozdamar (Izmir University of Economics, Turkey), Gilles Trombettoni (University of Nice – Sophia-Antipolis, France), Martine Ceberio, Vladik Kreinovich, and Michel Rueher.

Out of the 14 submitted papers, the following five papers were accepted for publications in the proceedings:

1. *On the Numerical Solution to Linear Problems Using Stochastic Arithmetic*, by René Alt, Jean-Luc Lamotte, and Svetoslav Markov.

2. *Quantum Versions of k-CSP Algorithms: a First Step Towards Quantum Algorithms for Interval-Related Constraint Satisfaction*, by Evgeny Dantsin, Alexander Wolpert, and Vladik Kreinovich.

3. *A Branch And Prune Algorithm for the Approximation of Non-Linear AE-Solution Sets*, by Alexandre Goldsztejn.

4. *Pseudozero Set of Interval Polynomials*, by Phillippe Langlois and Stef Graillat.

5. *Interval-Based Robust Statistical Techniques for Non-Negative Convex Functions, with Application to Timing Analysis of Computer Chips*, by Michael Orshansky, Wei-Shen Wang, Martine Ceberio, and Gang Xiang.

Also, the paper *Inner Approximation of Distance Constraints with Existential Quantification of Parameters*, by Carlos Grandon and Alexandre Goldsztejn, was accepted as a poster.

3 Acknowledgments

We want to thank all authors, and all reviewers of our RCA track at SAC 2006. We are also grateful to the Symposium General Program Chairs, with the help and efforts of whom the organization of this track was made possible.