PROJECT OBJECTIVES: define static analysis frameworks for control programs involving numerical computations, non-deterministic and probabilistic behaviours.

1. Define an appropriate semantics for non-deterministic and probabilistic behaviours.
2. Build an abstraction of it for the static analysis of complex programs and test case generation.
3. Refine the analysis for the problem of floating-point computations using formal proof techniques.

MAIN RESULTS

**A new library for P-Box arithmetic.**
- An extension of affine arithmetic to reason about imprecise probabilities.
- A C++ library that shows to be faster and often more precise than existing tools for imprecise probabilities.

**A new semantics for programs with imprecise inputs.**
- A semantics for numerical programs with inputs given as sets of probability distributions.
- A proof of the correctness of the probabilistic affine forms w.r.t this concrete semantics.

**Signal reconstruction over noisy channels.**
- New method to reconstruct a quantized signal over noisy channel.
- Algorithm based on P-Boxes that does not use on a possibly false apriori.
- More efficient than classical techniques in presence of high noise.

**Robustness proofs for finite-precision programs.**
- New notion of robustness for programs, equivalent to the Lipschitz stability.
- New global method for proving the robustness of a while-loop
- Uses global properties of the loop structure.

HIGHLIGHTS

**Uncertainty propagation through a non-linear differential equation**
Bound the solution of \( \dot{x}_1 = \theta_1 x_1 (1 - x_2) \) and \( \dot{x}_2 = \theta_2 x_2 (x_1 - 1) \) when the parameters \( \theta_1 \) and \( \theta_2 \) are given by P-Boxes

- Used VSPODE to express \( x_1 \) as a polynomial of \( \theta_1 \)
- Used our C++ library to evaluate this polynomial.
- Result is more precise and obtained faster than in [5]

- Used VSPODE to express \( x_2 \) as a polynomial of \( \theta_2 \)
- Result is more precise and obtained faster than in [5]

- Used VSPODE to express \( x_1 \) and \( x_2 \) as polynomials of \( \theta_1 \) and \( \theta_2 \)

**CONCLUSION AND PERSPECTIVES**

CPP was very fruitful, and brought forth valuable contributions to the analysis of non-deterministic, probabilistic, numerical devices:
1. new semantical models and proof techniques
2. new algorithms, more precise, faster, based on P-boxes
3. new software prototypes implementing the above.

As perspectives, and while P-box based algorithms were extremely successful, moment-based algorithms or algorithms based on bounds of Z-transforms should be explored as well.

CONTACT:
goubault@lsv.ens-cachan.fr

REFERENCES