Research and Scholarship

Contents

1 Evidence of Success in Research and Publication

1.1 Research Overview

My main drive in conducting research in computer science is to enhance decision-making processes: automating decisions while ensuring reliability of the process and the outcome. Most of the decisions I try to automate involve numerical models.

The core of my research is in numerical constraint solving (NCS) and interval computations. My research interests mainly lie in the area of non-linear continuous constraint and global optimization solving, along with the many applications of these.

Some background: *Numerical constraint solving (NCS) techniques are important components of intelligent systems. They can efficiently tackle hard continuous nonlinear problems, such as financial analysis, simulation and synthesis of electronic circuits, failure diagnosis, decision support systems, molecular biology, geometrical problems. NCS (propagation) techniques made formerly intractable problems very practical: e.g., one famous circuit design problem from Ebers and Moll, formerly solved with a precision of four significant digits in fourteen months using a network of 31 workstations, could be solved in a couple of milliseconds on one workstation thanks to constraint solving algorithms.*

NCS is different from (constraint) logic programming (LP). Constraint programming (CP) is a declarative way of programming. It can only be related to LP as an offspring of it. Constraint Logic Programming (CLP) first extended logic programming by including new kinds of predicates called constraints, which are not necessarily clauses, and are therefore handled differently by the constraint solver. Constraint solvers also extend logic programming solving processes by including solving procedures other than backwards reasoning, in particular constraint propagation. CLP is dedicated to combinatorial, discrete problems. It was extended to Constraint Programming (CP), handling more solving procedures and continuous problems. It is important to note that the field is usually divided into two main research streams: constraints over discrete domains (leading to work on combinatorial problems), and constraints over continuous domains (leading to mostly work on non-linear problems). NCS is dedicated to the latter.

The power of constraint programming, and NCS in particular, has attracted the attention of major companies, s.a. manufacturers Michelin and Dassault, the French railway authority SNCF, airlines Swissair, SAS, and Cathay Pacific, and Hong Kong International Terminals. Nevertheless, NCS has yet to address a lot of challenges, and research in this field is very active. One of them is the lack of knowledge of researchers and domain scientists about constraints in general and their use in decision making processes, making NCS techniques under-utilized in real-world scientific projects.

In this context, my research goals are to:

- make non-linear continuous constraint and global optimization problems solvers scalable, while remaining reliable (w.r.t. notions such as globality, completeness, robustness); and

- bridge the gap between the practicality of the solvers and their lack of use by practitioners, by building a community of decision-making researchers and domain scientists.

In doing this, I seek to make an impact on the way problems are solved and which problems can be solved. I believe that this is a high payoff area. My efforts in achieving these goals result in balancing my work between fundamental (Goal 1 – G1) and applied research (Goal 2 – G2):

- part of my work is in exploring new computational models and designing ways to make more computations faster: I work in the areas of symbolic-numeric algorithms for constraint and optimization solving, multi-criteria decision making, interval computations (e.g., through the use of different paradigms – J2 of my CV –, the design of new interval arithmetic – C1 –, or combinations of solvers – C3 –); and
- part is in exploring applications as both a way of getting feedback and (mostly) a creativity boost: network security, bio-medical engineering, software engineering (e.g., J1, C6, C19, Ch2).

1.2 Highlights of Research Successes and Impacts

Consistent with my two main goals as stated above, I have contributed to the following areas:

1.2.1 Decision making

My work in the area of decision making revolves around the following topics: constraint solving, multi-criteria decision making, optimization, and uncertainty. These are the essential components of what I am striving to build: tools for more efficient (mostly numerical) problem solving. Constraints are for the hard requirements of the problems, multi-criteria decision making help model the soft part, optimization is often what decision comes down to, and uncertainty is part of all numerical models I consider as I explain below.

□ **Constraint solving.**

As mentioned before, I am mostly interested in solving constraints as they are part of most of the decision processes I will address. Over the last years, I have explored ideas to speed up the solving process. The main directions I have pursued and contributed to are the following:

- **Speculations** to speed up the constraint solving process in a distributed decision setting. The idea was to acknowledge two very likely scenarios: (1) decisions are likely to be made at different geographical locations or at least not only by one single decision maker; (2) in such a setting, partial decisions might be delayed and might even never be provided (e.g., communication failure).

I worked on this with my colleagues, Drs. Satoh and Hosobe, from the National Institute of Informatics in Tokyo, Japan, where I spent a total of about 2 months as an invited researcher (spanning from spring 2004 to spring 2005)[1]. In this joint work, that assumed a master-slave setting, we proposed and developed an operational procedure to speculate and revise beliefs about the partial solution of the addressed problem (see articles Ch4 and C22).

I later proposed to extend this work to a more general setting. This work is planned to be carried out under grant NSF CAREER#0953339.

- Efficient **search space exploration** can significantly speed up the solving process. In particular, the traditional constraint solving approach using intervals (boxes) to model the full search space and ensure reliability relies on an exploration of the search space of the type: branch-and-prune (or branch-and-narrow, or any variation of these). This means that branching will occur at some point: it is actually very critical since it will allow to separate solutions. Extensive research and proposals exist on how to branch / bisect the search space.

  This joint work with Linet Ozdamar (at the time of the article, from Nanyang Singapore, and now at Izmir University in Turkey) proposed an interval partitioning technique, to guide the search, based on simple local search (see article J12).

- Different **computation paradigms**. Recently, I have looked into possibilities to use circular interval arithmetic, as opposed to box / rectangular interval arithmetic. We approached the problem geometrically, considered different sub-search spaces, such as ellipsoids, and proposed an efficient bisection for these (see article C1). This was to be put in the context of exploration / search algorithms based with the need of branching. I plan to extend this line of research to optimization by using it as a way to detect basins to "dive" into.

  With my colleague, Dr. Kreinovich, as well as with my students (but with them, from the application point of view), I have also explored the use of tensors (see article J2).

□ Multi-criteria decision making (MCDM) and optimization.

I view MCDM as a natural extension of my previous dissertation work on soft constraints. It is concerned with processes when one has to make a decision based on several, possibly conflicting, criteria. The decision consists in general in a "reasonable" or best tradeoff between the satisfaction of these criteria. In this sense, it is very similar to the concept of soft constraints, for which when constraints can't be met at once, a tradeoff will be sought. The main conceptual difference is that in MCDM there is no requirement that safe values of the criteria satisfaction be defined, as is the case in constraints (feasible / unfeasible regions are modeled).

The preferred approach, used and developed over the years I have worked on MCDM, was that of using a Choquet integral and fuzzy measures to combine the criteria satisfaction levels. This work was conducted in large part in collaboration with Dr. Modave (at that time from CS at UTEP, now at Texas Tech University Health Center in El Paso). My contributions to the area of MCDM are at various levels.

- **Interval MCDM.** The approach to MCDM based on the use of fuzzy measures heavily relies on the existence of such a fuzzy measure. In theory, experts would be queried to

[1] This collaboration started with the Sakura project – see list of grants in vitae and article J11 –.

provide meaningful such values. In practice, it is not a reasonable approach for two reasons: (1) for a problem involving n criteria, $2^n - 2$ values need to be provided; (2) values of the fuzzy measures are meaningless to an expert and therefore the odds of getting meaningful values are very low.

Instead, we assumed that giving the possibility of providing intervals / ranges of values rather than "exact" values would be more practical. This required us to revisit the computation through the Choquet integral and make sure that the interval computations involved would not result in an "explosion" of the interval width (which could have been dramatic for the meaningfulness of the result). Instead, we showed that no such "explosion" would occur (see articles C27, C28, and Ch3).

To later address the ambiguity created by interval decisions, we proposed strategies to interpret the interval results (see article C9).

This line of work significantly contributed to the area of MCDM by allowing more flexibility and practicality to the setting, as well as by providing ways to interpret the subsequent results in a meaningful and strategic way.

- **Fuzzy measure extraction through constraints and optimization**

  This work was mostly conducted with students.

  As an improvement to the above-outlined problem of the need for a fuzzy measure, I also worked on the possibility of extracting fuzzy measures from sample data. For instance, let's say that we want to assess the quality of software. We have access to an expert's assessments of some pieces of code. For each of these pieces of code, we can objectively assess (or get the expert's opinion on) the level of satisfaction of each of the criteria. We will use these data to reverse engineer the fuzzy measure that models this expert's reasoning. We call this "fuzzy measure extraction".

  Our approach to doing so was to model and solve the problem as an optimization problem. Originally it is a pure constraint problem if the expert is always very consistent in his/her assessments, but that would be seldom the case, hence failing the constraints. As a result, we aim at determining the fuzzy measure values that best model the expert's assessments.

  To solve this problem, we tuned a bees algorithm and showed improvement in the speed and scalability of the extraction process (see article C3 – best student paper award at NAFIPS'11). In an aim to conduct a reliable solving process, we then combined this algorithm with an interval solver: this resulted in speeding the process and providing even better solution results (the corresponding journal article is in progress). We are currently working on slight modification of the monotonicity constraints to speed up the process even more. Our promising results are work in progress to be submitted soon.

☐ **Uncertainty and interval computations.**

Most of my work is concerned with problems that can be expressed with variables of continuous ranges. Aiming at complete/global solving processes, I usually model the variables' ranges using intervals and then conduct computations with these. The potential overestimation resulting from interval computations, as well as the mere fact that intervals are not as sharp as single values, generates a need for more information, or strategies of choice (as already pointed out with C9). Also, the models I work with come from potentially uncertain sources: for instance, from measurements that are never 100% accurate. As a result, my research deals with uncertainty and resulted in several contributions, ranging from affine-arithmetic-type techniques for uncertainty handling in expert systems (J9 and C16 from a different angle), a combination of probabilistic and interval uncertainty in engineering calculations (J10, and also for instance C13 and C19).

1.2.2 Applications

As mentioned earlier, I value applications because (1) they provide a nice way to show the applicability and practicality of my research findings (hence promoting the field as is my goal G2), and (2) they usually bring new consideration to my thinking process (configurations I would otherwise not have thought about, new kinds of complex problems that need to be addressed and deserved a different solving approach, etc.).

As a result, over the years, I have considered various domains of applications: some of which more on the side of pure applications, most of them more as starting point for new solving techniques. In particular, I have worked on varied topics such as:

- Engineering applications: soft constraints applied to the diagnosis of shock absorbers for cars (C23)
- Bio-medical engineering application, namely Gait Therapy: constraints applied to the determination of healthy gaits, to help diagnose abonormal ones (C8, C10, C11, C12).
- Network security (C6, C14, C24)
- Software engineering (C5, C7)
- Investment portfolios (Ch2)

1.3 Impact on Community

I have also devoted part of my time building a community of people federated around a common interest in decision-making and usually decision problems of numerical nature (although not restricted to). My efforts have spanned in two complementary directions: (1) building and maintaining a community website; (2) organizing a series of annual workshops, CoProD, that brings together exactly these kind of people: decision-making researchers with domain scientists. Both efforts have been successful so far.

The community website I have designed and that I maintain with my research group students is http://www.constraintsolving.com. It was released in July 2007 and it now receives a steady attention from the community with about over 1,000 unique visitors a month. Recently I was approached by a researcher at Siemens to include their geometric constraint solvers on constraintsolving.com, which we did[2]. I also use this website as a reference for an introduction to constraints

[2]Evidence of this request is available in appendix of this section.

for all students who are new to my research group: they then get to add to it as they see fit (e.g., the FAQ part of it, or others).

I first organized CoProD in fall 2008 (see http://coprod.cs.utep.edu) as a satellite event of the 13th GAMM - IMACS International Symposium on Scientific Computing, Computer Arithmetic and Verified Numerical Computations SCAN'08 that was held at UTEP (I was co-chair of this international conference, see http://www.scan2008.com for more information). Each of the workshops since then gathered about 30 people from the national and international community, ranging from high-school students that I host as interns during summer to very prominent researchers in decision making and in applied fields, such as Rina Dechter from UC Irvine (2009) and Xiaobai Sun from Duke University (2011). CoProD is hosted at UTEP every odd year and at the location of the SCAN conference on even years: the next meeting will be in Novosibirsk, Russia in Fall 2012.

1.4 List of articles in refereed scholarly journals

Important note: In the lists below, the names of authors who were students at the time we wrote the article are followed by an "".*

J1 Aline Jaimes*, Craig Tweedy, Tanja Magoc*, Vladik Kreinovich, and Martine Ceberio, "Selecting the Best Location for a Meteorological Tower: A Case Study of Multi-Objective Constraint Optimization", **Journal of Uncertain Systems**, 2010, Vol. 4, No. 3.

J2 Martine Ceberio and Vladik Kreinovich, "Computing with Tensors: Potential Applications of Physics-Motivated Mathematics to Computer Science", **Journal of Uncertain Systems**, 2010, Vol. 4, No. 3.

J3 Martine Ceberio and Vladik Kreinovich, "Diagonalization is also practically useful: a geometric idea", **Geombinatorics**, 2010, Vol. 20, No. 1, pp. 15-20.

J4 Omar Ochoa*, Martine Ceberio, and Vladik Kreinovich, "How to Describe Spatial Resolution: An Approach Similar to the Central Limit Theorem", **Applied Mathematical Sciences**, 2010, Vol. 4, No. 63, pp. 3153-3160.

J5 Martine Ceberio, Vladik Kreinovich, Gunter Mayer, "For Complex Intervals, Exact Range Computation Is NP-Hard Even for Single Use Expressions (Even for the Product)", **Reliable Computing Journal**, 2007.

J6 Daniel Berleant, Martine Ceberio, Gang Xiang*, Vladik Kreinovich, "Towards Adding Probabilities and Correlations to Interval Computations", **International Journal of Approximate Reasoning**, 2007.

J7 Gang Xiang*, Martine Ceberio, Vladik Kreinovich, "Computing Population Variance and Entropy under Interval Uncertainty: Linear Time Algorithms", **Reliable Computing**, 2007.

J8 Martine Ceberio, Scott Ferson, Vladik Kreinovich, Sanjeev Chopra*, Gang Xiang*, Adrian Murguia*, and Jorge Santillan*, "How To Take Into Account Dependence Between the Inputs: From Interval Computations to Constraint-Related Set Computations, with Potential Applications to Nuclear Safety, Bio- and Geosciences", **Journal of Uncertain Systems**, 2007.

J9 Martine Ceberio, Vladik Kreinovich, Sanjeev Chopra*, Luc Longpre, Hung T. Nguyen, Bertram Ludaescher, and Chitta Baral, "Interval-Type and Affine Arithmetic-Type Techniques for Handling Uncertainty in Expert Systems", **Journal of Computational and Applied Mathematics**, 2007, Vol. 199, No. 2, pp. 403–410.

J10 Scott Starks, Vladik Kreinovich, Luc Longpré, Martine Ceberio, Gang Xiang*, Roberto Araiza*, Jan Beck, Radhi Kandathi*, A. Nayak, and Roberto Torres*, "Towards Combining Probabilistic and Interval Uncertainty in Engineering Calculations: Algorithms for Computing Statistics under Interval Uncertainty, and Their Computational Complexity", **Reliable Computing**, Vol. 12, No 6, pp. 471–501, Dec. 2006.

J11 Frédéric Benhamou, Martine Ceberio, Philippe Codognet, Hiroshi Hosobe, Christophe Jermann, Ken Satoh, Kasunori Ueda, "Franco-Japanese Research Collaboration in Constraint Programming, R&D Project Report", **Progress in Informatics**, no 3, pp. 59-65, 2006.

J12 Chandra S. Pedamallu*, Linet Ozdamar, Martine Ceberio, "Efficient Interval Partitioning – Local Search Collaboration for Constraint Satisfaction", **Journal on Computers and Operations Research**, 2006.

J13 Martine Ceberio and Vladik Kreinovich, "Fast Multiplication of Interval Matrices (Interval Version of Strassen's Algorithm)", **Reliable Computing**, Vol. 10, No. 3, pp. 241-243, April 2004.

J14 Martine Ceberio and Vladik Kreinovich, "Greedy Algorithms for Optimizing Multivariate Horner Schemes", in **ACM-SIGSAM Bulletin**, Vol. 38, No. 1 (147), pp. 8-15, March 2004.

J15 Martine Ceberio, Laurent Granvilliers, "Horner's Rule for Interval Evaluation Revisited", **Computing**, Vol. 69, No 1, pp. 51–81, 2002.

1.5 List of articles in conference proceedings

C1 Paden Portillo*, Martine Ceberio, and Vladik Kreinovich, "Towards an Efficient Bisection of Ellipsoids", Proceedings of the ITEA Live-Virtual-Constructive Conference "Test and Evaluation", El Paso, Texas, January 24-27, 2011.

C2 Karen Villaverde, Olga Kosheleva, and Martine Ceberio, "Computations under Time Constraints: Algorithms Developed for Fuzzy Computations Can Help", Proceedings of **NAFIPS 2011, the North American Fuzzy Information Processing Society**, 2011.

C3 Xiaojing Wang*, Jeremy Cummins*, and Martine Ceberio, "The Bees Algorithm to Extract Fuzzy Measures from Sample Data", *best student paper award*, Proceedings of **NAFIPS 2011, the North American Fuzzy Information Processing Society**, 2011. Best Student Paper Award (first place).

C4 Aline Jaimes, Craig Tweedie, Tanja Magoc*, Vladik Kreinovich, and Martine Ceberio, "Multi-Objective Optimization under Positivity Constraints, with a Meteorological Example", Proceedings of the **IEEE World Congress on Computational Intelligence WCCI'2010**, Barcelona, Spain, July 18-23, 2010, pp. 2355-2361.

C5 Carlos Acosta* and Martine Ceberio, "A Constraint-Based Approach to Verification of Programs with Floating-Point Numbers", in the Proceedings of **SERP'08 - the 2008 International Conference on Software Engineering Research and Practice**, 2008.

C6 Martine Ceberio and Christian Servin*, "Cascade Vulnerability Problem Simulator Tool", in the Proceedings of **the 2008 International Conference on Modeling, Simulation and Visualization Methods, MSV'08**, pp. 227–231, 2008.

C7 Yoonsik Cheon, Antonio Cortes*, Martine Ceberio, and Gary T. Leavens, "Integrating Random Testing with Constraints for Improved Efficiency and Diversity", in **the 20th International Conference on Software Engineering and Knowledge Engineering, SEKE'08**, San Francisco Bay, California, USA, July 1–3, 2008.

C8 Roberto Araiza*, Martine Ceberio, Naga Suman Kanagala*, Vladik Kreinovich, and Gang Xiang*, "Applications of 1-D Versions of Image Referencing Techniques to Hydrology and to Patient Rehabilitation", in the proceedings of **NAFIPS 2008, the North American Fuzzy Information Processing Society**, 2008.

C9 Tanja Magoč*, Martine Ceberio, and François Modave, "Interval-based Multi-Criteria Decision Making: Strategies to Order Intervals", in the proceedings of **NAFIPS 2008, the North American Fuzzy Information Processing Society**, 2008.

C10 Naga Suman Kanagala*, Martine Ceberio, Thompson Sarkodie-Gyan, Vladik Kreinovich, and Roberto Araiza*, "Identification of Human Gait in Neuro-Rehabilitation: Towards Efficient Algorithms", in the Proceedings of the **24th Southern Biomedical Engineering Conference**, Eds. H. Nazeran, M. Goldman, and R. Schoephoerster, Medical and Engineering Publishers, pp. 153–156, 2008.

C11 Richard D. Brower, Martine Ceberio, Patricia Nava, Thompson Sarkodie-Gyan, Huiying Yu*, "Identification of Human Gait using Fuzzy Inferential Reasoning", in the Proceedings of **ICORR'07, the 10th International Conference On Rehabilitation Robotics**, Netherlands, 2007.

C12 Richard Brower, Martine Ceberio, Chad MacDonald*, Thompson Sarkodie-Gyan, "Determination of Human Gait Phase Using Fuzzy Inference", in the Proceedings of **ICORR'07, the 10th International Conference On Rehabilitation Robotics**, Netherlands, 2007.

C13 Martine Ceberio, Vladik Kreinovich, Andrzej Pownuk, and Barnabas Bede, "From Interval Computations to Constraint-Related Set Computations: Towards Faster Estimation of Statistics and ODEs under Interval, p-Box, and Fuzzy Uncertainty", in the proceedings of **IFSA'07 World Congress, the International Fuzzy Systems Association** (Main theme: Theory and Applications of Fuzzy Logic and Soft Computing), 2007.

C14 Stefano Bistarelli, Martine Ceberio, Eric Freudenthal, and Christian Servin*, "An Optimization Approach to the Cascade Vulnerability Problem using Soft Constraints", in the proceedings of **NAFIPS 2007, the North American Fuzzy Information Processing Society**.

C15 Michael Orshansky, Wei-Shen Wang, Martine Ceberio, Gang Xiang*, "Interval-based Robust Statistical Techniques for Non-negative Convex Functions, with Application to Timing Analysis of Computer Chips", in the proceedings of **the 21st International Symposium on Applied Computing, SAC'06**, 2006.

C16 Martine Ceberio, Richard Coy*, François Modave, "Multi-criteria Decision Making for Assisted Design", in the proceedings of **IPMU'06, Information Processing and Management of Uncertainty in Knowledge-based Systems**, pp. 1567–1574, 2006.

C17 Evgeny Dantsin, Alexander Wolpert, Martine Ceberio, Gang Xiang*, and Vladik Kreinovich, "Detecting Outliers under Interval Uncertainty: A New Algorithm Based on Constraint Satisfaction", in the proceedings of **IPMU 2006, Information Processing and Management of Uncertainty in Knowledge-based Systems**, 2006.

C18 Olga Kosheleva and Martine Ceberio, "Processing Educational Data: From Traditional Statistical Techniques to an Appropriate Combination of Probabilistic, Interval, and Fuzzy Approaches", in the Proceedings of the **International Conference FNG'05, , Information Processing and Management of Uncertainty in Knowledge-based Systems**, 2005.

C19 Martine Ceberio, G. Randy Keller, Olga Kosheleva, Vladik Kreinovich, Roberto Araiza*, M. Averill*, and Gang Xiang*, "Data Processing in the Presence of Interval Uncertainty and Erroneous Measurements: Practical Problems, Results, Challenges", in the Proceedings of the **Second Scandinavian Workshop on Interval Methods And Their Applications**, 2005.

C20 Martine Ceberio and Vladik Kreinovich, "Towards an Optimal Approach to Soft Constraint Problems", in the Proceedings of the **17th IMACS World Congress Scientific Computation, Applied Mathematics and Simulation (IMACS)**, 2005.

C21 Martine Ceberio, Vladik Kreinovich, Sanjeev Chopra*, Bertrand Ludaescher, and Emad Saad*, "Taylor Model-type Techniques for Hanlding Uncertainty in Expert Systems, with Potential Applications to Geoinformatics", in the Proceedings of the **17th IMACS World Congress Scientific Computation, Applied Mathematics and Simulation (IMACS'05)**, 2005.

C22 Martine Ceberio, Ken Satoh, and Hiroshi Hosobe, "Speculative Constraint Processing with Iterative Revision for Disjunctive Answers", in the proceedings of **CLIMA IV, Computational Logic in Multi-agent Systems**, pp.119–134, 2005.

C23 Martine Ceberio and Richard Coy*, "Enhancement of Parameter Estimation using Flexible Constraints: an Application to Shock-response Study", in the Proceedings of **"Algorithmic Mathematics and Computer Science" (AMCS'05)**, 2005.

C24 François Modave, Martine Ceberio, Xiaojing Wang*, Olga Garay*, R. Ramirez*, and R. Tejada*, "Comparison of Computer Attacks: an Application of Interval-based Fuzzy Integration", in the Proceedings of **NAFIPS'05, the North American Fuzzy Information Processing Society**, 2005.

C25 Martine Ceberio, François Modave, and Xiaojing Wang*, "Comparing Attacks: an Approach Based on Interval Computations and Fuzzy Integration", in the Proceedings of **FuzzIEEE'05, the IEEE International Conference on Fuzzy Systems**, 2005.

C26 P. Jaksurat, Eric Freudenthal, Martine Ceberio, and Vladik Kreinovich, "Probabilistic Approach to Trust: Ideas, Algorithms, and Simulations", in the Proceedings of the **5th International Conference on Intelligent Technologies (InTech'04)**, 2004.

C27 Martine Ceberio and François Modave, "An Interval-valued, 2-additive Choquet Integral for Multicriteria Decision Making", in the proceedings of **IPMU 2004, Information Processing and Management of Uncertainty in Knowledge-based Systems**, 2004.

C28 Martine Ceberio and François Modave, "Interval-Based Multicriteria Decision Making", in the Proceedings of **AI+MATH'04, the International Symposium on Artificial Intelligence and Mathematics**, 2004.

C29 Martine Ceberio, Laurent Granvilliers, "Solving Nonlinear Equations by Abstraction, Gaussian Elimination, and Interval Methods", in the proceedings of **FroCos 2002**, pp 117-131, 2002.

C30 Martine Ceberio, Laurent Granvilliers, "Solving Nonlinear Systems by Constraint Inversion and Interval Arithmetic", in the proceedings of **AISC 2000**, pp 127-141, 2000.

1.6 Chapters in Scholarly Books and Monographs

Ch1 Martine Ceberio, Vladik Kreinovich, Andrzej Pownuk, and Barnabas Bede, "From Interval Computations to Constraint-Related Set Computations: Towards Faster Estimation of Statistics and ODEs Under Interval, P-Box, and Fuzzy Uncertainty", In: JingTao Yao (ed.), **Novel Developments in Granular Computing: Applications for Advanced Human Reasoning and Soft Computation**, IGI Global Publisher, pp. 131-147, 2010.

Ch2 Tanja Magoč*, François Modave, Vladik Kreinovich, and Martine Ceberio, "Risk Management in Investment Portfolios: The Use Of Fuzzy Measures, Fuzzy Integrals and Constraint Programming", Aboul-Ella Hassanien and Ajith Abraham (Eds), Foundations on Computational Intelligence, in **Studies in Computational Intelligence**, Springer Verlag, Vol. 202/2009, pp 133-173, 2009.

Ch3 Hung T. Nguyen, Vladik Kreinovich, Francois Modave, and Martine Ceberio, "Fuzzy Without Fuzzy: Why Fuzzy-Related Aggregation Techniques Are Often Better Even in Situations Without True Fuzziness", Aboul-Ella Hassanien and Ajith Abraham (Eds), Foundations of Computational Intelligence, Springer-Verlag, 2009, Vol. 2, pp. 27-51.

Ch4 Martine Ceberio and François Modave, "Interval-based Multicriteria Decision Making", in **Modern Information Processing: From Theory to Applications**, edited by B. Bouchon-Meunier, G. Coletti, R. R. Yager (Eds), Elsevier Mathematics, pp. 281–294, 2006.

Ch5 Martine Ceberio, Ken Satoh, and Hiroshi Hosobe, "Speculative Constraint Processing with Multi-Agent Belief Revision", in Francesca Toni and Paolo Torroni (Eds.), **Computational Logic in Multi-Agent Systems** – CLIMA VI (Post-Proceedings of the 6th International Workshop on Computational Logic in Multi-Agent Systems), Lecture Notes in Artificial Intelligence, Vol. 3900, pp. 340–357, Springer-Verlag, 2006.

1.7 List of articles in refereed Workshop Proceedings (W) and abstracts (A)

W1 Aline Jaimes, Craig Tweedie, Tanja Magoc*, Vladik Kreinovich, and Martine Ceberio, "Optimal Sensor Placement in Environmental Research: Designing a Sensor Network under Uncertainty", In: Michael Beer, Rafi L. Muhanna, and Robert L. Mullen (Eds.), Proceedings of the **4th International Workshop on Reliable Engineering Computing REC'2010**, Singapore, March 3-5, 2010, pp. 255-267.

W2 Martine Ceberio, Vladik Kreinovich, Andrzej Pownuk, "Constraint-Related Set Computations: A New FEM-Motivated Approach to Propagating Uncertainty", in the proceedings of **FEMTEC'09**.

W3 Paulo Pinheiro Da Silva, Martine Ceberio, Christian Servin*, Vladik Kreinovich, "Propagation and Provenance of Probabilistic and Interval Uncertainty in Cyberinfrastructure-Related Data Processing", in the proceedings of **the NSF Workshop on Reliable Engineering Computing, REC'08**.

W4 Martine Ceberio, Scott Ferson, Vladik Kreinovich, Sanjeev Chopra*, Gang Xiang*, "How to Take into Account Dependence Between the Inputs: From Interval Computations to Constraint-Related Set Computations, With Potential Applications to Nuclear Safety, Bio- and Geosciences", in the proceedings of **the NSF Workshop on Reliable Engineering Computing, REC'06**, 2006.

W5 Martine Ceberio, Vladik Kreinovich, and Lev Ginzburg, "On the Use of Intervals in Scientific Computing: What is the Best Transition from Linear to Quadratic Approximation?", in the Proceedings of the **Second Scandinavian Workshop on Interval Methods And Their Applications**, 2005.

W6 Scott Starks, Vladik Kreinovich, Luc Longpré, Martine Ceberio, Gang Xiang*, Roberto Araiza*, Jan Beck*, Rathi Kandathi, A. Nayak, and Roberto Torres*, "Towards Combining Probabilistic and Interval Uncertainty in Engineering Calculations", in the proceedings of the **NSF Workshop on Reliable Engineering Computing**, pp. 193–213, 2004.

W7 Martine Ceberio, Vladik Kreinovich and Lev Ginzburg, "Towards Joint Use of Probabilities and Intervals in Scientific Computing: What is the Best Transition from Linear to Quadratic Approximation?", in the Proceedings of the **Workshop on State-of-the-Art in Scientific Computing (PARA'04)**, 2004.

A1 Uram Anibal Sosa Aguirre*, Martine Ceberio, and Vladik Kreinovich, "Why Curvature in L-Curve: Combining Soft Constraints", in the book of abstracts of **CoProD'11**, 2011.

A2 Olga Kosheleva, Martine Ceberio, and Vladik Kreinovich, "Adding Constraints: A (Seemingly Counterintuitive but) Useful Heuristic in Solving Difficult Problems", in the book of abstracts of **CoProD'11**, 2011.

A3 Shubhra Datta*, Martine Ceberio, Mario Bencomo*, and George Moreno*, "On the Practicality of Constraint-Based Program Verification", in the proceedings of **SCAN'10**, 2010.

A4 Karen Villaverde, Olga Kosheleva, and Martine Ceberio, "Why Ellipsoid Constraints, Ellipsoid Clusters, and Riemannian Space-Time: Dvoretzky's Theorem Revisited", in the book of abstracts of **CoProD'10**, 2010.

A5 Vladik Kreinovich, Juan Ferret, and Martine Ceberio, "Constraint-Related Reinterpretation of Fundamental Physical Equations Can Serve as a Built-In Regularization", in the book of abstracts of **CoProD'10**, 2010.

A6 Paden Portillo*, Martine Ceberio, Vladik Kreinovich, "Towards an Efficient Bisection of Ellipsoids", in the book of abstracts of **CoProD'10**, 2010.

A7 Olga Kosheleva, Martine Ceberio, and Vladik Kreinovich, "Why Tensors?", in: Martine Ceberio (ed.), Abstracts of the **Second Workshop on Constraint Programming and Decision Making CoProD'09**, El Paso, Texas, November 9-10, 2009, pp. 20-23.

A8 Martine Ceberio and Vladik Kreinovich, "Continuous If-Then Statements Are Computable". In: Martine Ceberio (ed.), Abstracts of the **Second Workshop on Constraint Programming and Decision Making CoProD'09**, El Paso, Texas, November 9-10, 2009, pp. 11-14.

A9 Aline Jaimes, Craig Tweedy, Tanja Magoc*, Vladik Kreinovich, and Martine Ceberio, "Selecting the Best Location for a Meteorological Tower: A Case Study of Multi-Objective Constraint Optimization". In: Martine Ceberio (ed.), Abstracts of the **Second Workshop on Constraint Programming and Decision Making CoProD'09**, El Paso, Texas, November 9-10, 2009, pp. 56-60.

A10 Martine Ceberio, Vladik Kreinovich, Scott Ferson, Cliff Joslyn, "Adding Constraints to Situations when, in addition to Intervals, we also have Partial Information about Probabilities", in the proceedings of **SCAN'06** + published in the **post-proceedings of SCAN'06**, the GAMM - IMACS International Symposium on Scientific Computing, Computer Arithmetic and Verified Numerical Computations.

A11 Luc Longpré, Vladik Kreinovich, Eric Freudenthal, Martine Ceberio, Francois Modave, Neelabh Baijal*, Wei Chen, Vinod Chirayath, Gan Xiang*, and J. Ivan Vargas*, "Privacy, Protecting, Processing, and Measuring Loss", presented at the **South Central Information Security Symposium**, 2005.

A12 Martine Ceberio, Vladik Kreinovich, Luc Longpré, Emad Saad, Bertrand Ludäscher, Chitta Baral, and Hung T. Nguyen, "Affine Arithmetic-Type Techniques for Handling Uncertainty in Expert Systems, with Applications to Geoinformatics and Computer Security", in the Proceedings of the **11th GAMM-IMACS International Symposium on Scientific Computing, Computer Arithmetic, and Validated Numerics (SCAN'04)**, 2004.

2 Evidence of Success in Securing Extramural Funding

As documented below, I have consistently made efforts in acquiring external funding. My role in proposed projects has been a balance of PI, Co-PI, supporting faculty / external collaborator. Since September 2003, I have been able to secure from external funding agencies:

- $ 1,276,243 in federal funding, of which $ 596,091 as PI;
- 20,000 euros from European funding, of which 5,000 euros as PI.

2.1 Awarded Grants

1. **PI** (NSF CCF 0953339) CAREER: Symbolic-Numeric Constraint-Based Solutions for Real-World Scientific Problems. Duration: 01/01/2010 to 12/31/2014. Amount: $564,650.
   The goal of this on-going project is to make Numerical Constraint Solving (NCS) techniques better adapted to real-world needs while making it more accessible. In order to achieve the

goal, this project will concentrate on theory and algorithms at the crux of the efficiency, adaptability, and distributivity aspects of problem-solving techniques. I have started and will continue pursuing the following objectives: (1) to open NCS to novel techniques, improving scalability; (2) to assist users facing over-constrained problems; and (3) to extend the distributed use of NCS to reflect the emerging networked social structure. The results of the research objectives feed into the work carried out to pursue my education objectives: to enhance the problem-solving skills and interest in advanced studies for middle-school to undergraduate students; and to enhance the participation of women and Hispanics in computing. The work carried out under this project has already resulted in several publications (C1, C3, A3, A6), one of them won the best student paper award at NAFIPS'11.

2. **PI** (NSF CCF 0839052) Constraint Programming and Decision Making Workshop, CoProD'08. Duration: 08/15/2008 to 07/31/2010. Amount: $5,941.
   The goal of this series of workshops, CoProD'08 – 11, is to bring together NCS researchers and to address the gap between the great capacity of the NCS techniques and their limited use. Each of the 3 CoProD workshops brought together about 30 researchers, from the areas of decision making as well as practitioners. They generated fruitful discussions and enabled some new contacts/collaborations. CoProD's on-going activities consist in developing a website that will engage discussions between decision-making researchers and practitioners and organizing CoProD'12, to take place in 09/12 in Novosibirsk, Russia.

3. **Co-PI** (NSF OCI 0506429) SCI: Collaborative Research: DAPLDS - a Dynamically Adaptive Protein-Ligand Docking System based on Multi-Scale Modeling. Duration: 09/01/2005 to 01/01/2008. Amount: $680,152.
   The goal of this project was to explore the multi-scale nature of algorithmic adaptations in protein-ligand docking and develop computational methods and models that efficiently accommodate these adaptations by means of the immense computing power that can be harnessed through the Internet using public-resource computing.

4. **PI** (French Ministry of Research) Development of Collaborations on the Topic of Flexible Constraints and Symbolic Algorithms: Grant for expatriates to help establish collaborations between French researchers working abroad and French institutes. Duration: 2004 - 2006. Amount: 5,000 euros.

5. **External collaborator** (Egide - Europe) PAI Egide Sakura: French-Japanese project on Soft and Continuous Constraints Programming (SCooP-Sakura). Duration: 01/2004 to 12/2006. Amount: 15,000 euros.
   The goal of this project was to integrate all projects related to soft and / or continuous constraints between NII[3] and LINA[4]. The collaboration generated new projects, such as my joint work on speculative constraint solving, and resulted in another journal publication (J11).

<u>And supplements:</u>

6. **PI** (NSF CCF 1138173) CAREER: Symbolic-Numeric Constraint-Based Solutions for Real-World Scientific Problems. Supplement for REU students in 2011. Amount: $8,000.

7. **PI** (NSF CCF 1026257) CAREER: Symbolic-Numeric Constraint-Based Solutions for Real-World Scientific Problems. Supplement for REU students in 2010. Amount: $16,000.

[3]NII: National Institute of Informatics, Tokyo, Japan.
[4]LINA: Laboratoire d'Informatique de Nantes Atlantique, Nantes, France.

8. **PI** (NSF CCF 0951526) Constraint Programming and Decision Making Workshop, CoProD'08.Amount: $1,500.

2.2 Pending Grants

1. **UTEP PI** (NSF CNS 1138493) Collaborative Research: CE21, Type I: Attracting Students to Computing via Contextual Project-Based Learning. Duration: 01/01/2012 to 12/31/2014. Amount: $318,365.

2.3 Declined Grants

1. **Supporting faculty** (Italian Ministry of Research) Application for significant bilateral projects within the Joint Declaration following the 10th Review Conference on Scientific and Technological Cooperation between Italy and the United States. Duration: 2011 - 2013.
2. **UTEP PI** (NSF CNS 1042383) Collaborative Research: BPC-DP: Real Projects for Real Clients Courses in High Schools. Duration: 2011 - 2013. Amount: $184,960.
3. **PI** (NSF CCF 1026258) Constraint Programming and Decision Making Workshop, CoProD'08: REU supplement for 2010. Amount: $14,105.
4. **Co-PI** (NSF CCF 1018526) AF: RI: Small: Real-Time Automated Investment Algorithms. Duration: 2011 - 2013. Amount: $469,372.
5. **Supporting faculty** (NSF IGERT 1037451) IGERT Multiphysics Training and Education Program (μTEP). Duration: 2010-2015.
6. **Co-PI** (NSF CNS 0940510) BPC-LSA: Collaborative Research: RAMP-UP Recruitment And Motivational Program for Underrepresented Populations. Duration: 2011 - 2013. Amount: $416,792.
7. **UTEP PI** (NSF CNS 0940431) BPC-A: Collaborative Research: Real Projects for Real Clients Courses in High Schools. Duration: 2010 - 2012. Amount: $223,341.
8. **PI** (NSF CCF 0845359) CAREER: A Constraint-Based Real-World-Oriented Problem-Solving Tool. Duration: 2009 - 2013. Amount: $461,078.
9. **Co-PI** (NSF DUE 0837814) Collaborative Research CCLI Phase 1: Refining and Evaluating a Rigorous Problem-Driven Algorithms Course Designed to Foster Engagement and Understanding. Duration: 2009 - 2010. Amount: $74,003.
10. **Co-PI** (NSF IIS 0757600) Pilot: Collaborative Proposal: Refining and Evaluating a Creatively Engaging and Rigorous Problem-Driven Algorithms Course. Duration: 2008 - 2009. Amount: $94,995.
11. **Co-PI** (NSF CNS 0739273) BPC - DP: Under-Represented Minority Role Models: Participation of Women and Hispanics in Computing Academic Careers. Duration: 2008 - 2010. Amount: $426,562.

12. **Co-PI** (Army Research Laboratories) Decision Making and Constraint Pro- gramming for Information Operations Vulnerability and Survivability Assessment. Duration: 2007 - 2009. Amount: $366,000.

13. **Co-PI** (NSF-DoD) Interactive Risk Management Framework for Security Response to Nuclear Threats in Border Urban Areas. Duration: 2007 - 2009.

14. **Co-PI** (BAA-ONR) Model-Based Human Activity Recognition using Gait as the Biometric. Duration: 2007 - 2009. Amount: $500,000.

15. **Co-PI** (NIH-RO) Automated Diagnosis and Therapy in Human Gait Using the Methods of Computational Intelligence. Duration: 2006 - 2011. Amount: $2.5M.

16. **Co-PI** (NSF CNS 0634521) BPC-DP - Under-represented Minority Role Models: Participation of Women and Hispanics in Computational Biology Academic Careers. Duration: 2007 - 2009. Amount: $494,891.

17. **PI** (NSF IIS 0546817) CAREER: A Real-world-oriented and Constraint-based Tool for Problem-Solving. Duration: 2006 - 2010. Amount: $415,386.

18. **Co-PI** (NSF CCF 0515233) Decision making: a new approach bridging the gap between theory and practice. Duration: 2006 - 2008. Amount: $349,304.

19. **Co-PI** (NSF IIS 0412879) A Real-World Decision-Aid System: Foundations and Applications. Duration: 2005 - 2007. Amount: $393,005.

3 Evidence of Community, Regional, National, or International Research

As mentioned in my statement of philosophy, collaboration is very important for me: at the local level (with colleagues and students), national, and international levels. This trend of my philosophy shows in my list of publications, with a long list of co-authors (as detailed below), as well as on the list of grant proposals I have been involved in over the last 8 years. I yearn for collaborations as often as possible, as an opportunity to mentor (students), be mentored (by more senior colleagues), and seek innovation.

3.1 Co-authored Publications

All my publications were co-authored. *To help differentiate publications that were co-authored with colleagues, I am listing below, in Subsection 4.3, the publications in which the co-authors are only the student(s) mentored, myself and possibly another direct advisor of my students.*

I co-authored articles with 11 international colleagues from 8 different institutions and countries, with 13 colleagues at the regional and national levels from 12 different institutions, and with 12 colleagues at UTEP from 6 different departments (3 colleges).

Below is the list of all non-students co-authors along with their affiliation and the number of publications co-authored.

Co-author	Affiliation	# Publ.
International		
Frederic Benhamou	LINA, University of Nantes, France	1
Stefano Bistarelli	Dep. of Mathematics and Computer Science	2
	University of Perugia, Italy	
Philippe Codognet	University Pierre et Marie Curie (Paris 6)	1
	co-director, Japanese-French Laboratory for Infomatics (JFLI)	
	Information Technology Center, University of Tokyo	
Laurent Granvilliers	LINA, University of Nantes, France	3
Hiroshi Hosobe	National Institute of Informatics, Tokyo, Japan	3
Christophe Jermann	LINA, University of Nantes, France	1
Bertram Ludaescher	Universität Freiburg, Germany	3
Gunter Mayer	Numerische Mathematik, Institut für Mathematik	1
	Universität Rostock, Germany	
Linet Ozdamar	Izmir University of Economics, Turkey	1
Ken Satoh	National Institute of Informatics, Tokyo, Japan	3
Kasunori Ueda	Waseda University, Tokyo, Japan	1
National		
Scott Ferson	Applied Biomathematics, Setauket, New York	3
Daniel Berleant	University of Arkansas at Little Rock	1
Evgeny Dantsin	Department of Computer Science, Roosevelt University, Chicago, Michigan	1
Gary T. Leavens	Dept. of Electrical Engineering and Computer Science	1
	University of Central Florida, Orlando	
Richard D. Brower	Department of Medical Education and Department of Neurology	2
	Paul L. Foster School of Medicine	
	Texas Tech University Health Sciences Center	
Barnabas Bede	Department of Mathematics, The University of Texas-Pan American	2
Lev Ginzburg	Stony Brook University	2
Pattama Jaksurat	Department of Computer Science. Chiang Mai University, Thailand	1
Michael Orshansky	Department of Electrical and Computer Engineering	1
	The University of Texas at Austin	
Alexander Wolpert	Department of Computer Science, Roosevelt University, Illinois	1
Regional		
Cliff Joslyn	Los Alamos National Laboratory, New Mexico	1
Hung T Nguyen	Department of Mathematics, New Mexico State University	3
Karen Villaverde	Computer Science Department, New Mexico State University	2

UTEP		# Publ.
Yoonsik Cheon	Computer Science Department	1
Eric Freudenthal	Computer Science Department	3
Randy Keller	Department of Geological Sciences	1
Olga Kosheleva	Department of Teacher Education	7
Vladik Kreinovich	Computer Science Department	42
Luc Longpre	Computer Science Department	1
Francois Modave	(formerly) Computer Science Department	10
	(now) Paul L. Foster School of Medicine	
	Texas Tech University Health Sciences Center	
Paulo Pinheiro Da Silva	Computer Science Department	1
Andrzej Pownuk	Department of Mathematics	3
Thompson Sarkodie-Gyan	Department of Electrical and Computer Engineering	3
Scott Starks	Department of Electrical and Computer Engineering	2
Craig Tweedie	Department of Biological Sciences	4

3.2 Joint Grant Proposals

I have also collaborated on 19 joint proposals or projects, as Co-PI, external collaborator, or supporting faculty. Below is the list of proposal collaborators (PIs only), along with their institution, and the number of proposals written together.

Declined or pending		
Stefano Bistarelli	Dep. of Mathematics and Computer Science University of Perugia, Italy	1
Eric Freudenthal	Computer Science Department at UTEP	2
David Klappholz	Stevens Institute of Technology in New Jersey	3
Tanja Magoc	(then) Computer Science Department at UTEP (now) University of Maryland	1
Francois Modave	(then) Computer Science Department at UTEP (now) Paul L. Foster School of Medicine Texas Tech University Health Sciences Center	4
Steve Roach	Computer Science Department at UTEP	1
Thompson Sarkodie-Gyan	Department of Electrical and Computer Engineering at UTEP	3
Leticia Velazquez		2
Funded		
Frederic Benhamou	LINA, University of Nantes, France	1
Ken Satoh	NII, Tokyo, Japan	1
Michela Taufer	(then) Computer Science Department at UTEP (now) University of Delaware	1

4 Evidence of Involving Students

4.1 Number of students supported from extramural funding

Through the federal funding I received, I was able to support a number of students:

- **PhD students:**
  - Luis David Lopez whom I mentored within the DAPLDS project in 2004-2005: he only stayed a year and then left to follow his wife to the University of Delaware.
  - Aziza Aouhassi whom I mentored within my CAREER project during spring 2011: she only stayed a semester and went back to her country to get married.
- **Graduate students:**
  - Paden Portillo, fall 2010 / spring 2011: Paden is a graduate student in the Master's program of Software Engineering. I was able to support him during fall 2010 and spring 2011. He worked with me on circular interval arithmetic for constraint solvers. Paden has now decided to suspend his involvement in CR2G because of family reasons.
  - Mario Bencomo, 2011: I supported him most of his last year before graduation. He worked mostly on symbolic-numeric algorithms, on techniques to delete redundancies in

linear systems of inequalities, and on global constraints. He joined Rice's PhD program in Computational Sciences and Applied Maths in Summer 2011.

  - Christian Del Hoyo, since spring 2011: I have supported him since spring 2011. He has been working with me on a flexible constraint solver. He is expected to graduate in summer 2012.

- **Under-graduate students:**
  - Luis Carlos Gutierrez, since spring 2010.
  - Marisol Chacon, fall 2010.
  - Mario Bencomo, 2010.
  - George Moreno, spring 2010.
  - Paden Portillo, spring 2010.

4.2 Number of students involved in research but not supported from extramural funding

Besides the research students I have supported from extramural funding, I have also consistently involved students in my research, working in CR2G, my research group. I have a record of involving students at all levels: PhD students, Master's students, undergraduate students, and high-school students. Over the years, I have involved a total of 4 PhD students, 10 Master's students, about 20 undergraduate students, and 15 high-school students.

4.3 Articles co-authored with students

Most of my articles are co-authored with students. Below, I am only citing articles co-authored with students of mine, or with students that I was also mentoring closely.

J12 Chandra S. Pedamallu*, Linet Ozdamar, Martine Ceberio, "Efficient Interval Partitioning – Local Search Collaboration for Constraint Satisfaction", **Journal on Computers and Operations Research**, 2006.

Ch2 Tanja Magoč*, François Modave, Vladik Kreinovich, and Martine Ceberio, "Risk Management in Investment Portfolios: The Use Of Fuzzy Measures, Fuzzy Integrals and Constraint Programming", Aboul-Ella Hassanien and Ajith Abraham (Eds), Foundations on Computational Intelligence, in **Studies in Computational Intelligence**, Springer Verlag, Vol. 202/2009, pp 133-173, 2009.

C1 Paden Portillo*, Martine Ceberio, and Vladik Kreinovich, "Towards an Efficient Bisection of Ellipsoids", Proceedings of the ITEA Live-Virtual-Constructive Conference "Test and Evaluation", El Paso, Texas, January 24-27, 2011.

C3 Xiaojing Wang*, Jeremy Cummins*, and Martine Ceberio, "The Bees Algorithm to Extract Fuzzy Measures from Sample Data", *best student paper award*, Proceedings of **NAFIPS 2011, the North American Fuzzy Information Processing Society**, 2011. Best Student Paper Award (first place).

C5 Carlos Acosta* and Martine Ceberio, "A Constraint-Based Approach to Verification of Programs with Floating-Point Numbers", in the Proceedings of **SERP'08 - the 2008 International Conference on Software Engineering Research and Practice**, 2008.

C6 Martine Ceberio and Christian Servin*, "Cascade Vulnerability Problem Simulator Tool", in the Proceedings of **the 2008 International Conference on Modeling, Simulation and Visualization Methods, MSV'08**, pp. 227–231, 2008.

C8 Roberto Araiza*, Martine Ceberio, Naga Suman Kanagala*, Vladik Kreinovich, and Gang Xiang*, "Applications of 1-D Versions of Image Referencing Techniques to Hydrology and to Patient Rehabilitation", in the proceedings of **NAFIPS 2008, the North American Fuzzy Information Processing Society**, 2008.

C9 Tanja Magoč*, Martine Ceberio, and François Modave, "Interval-based Multi-Criteria Decision Making: Strategies to Order Intervals", in the proceedings of **NAFIPS 2008, the North American Fuzzy Information Processing Society**, 2008.

C10 Naga Suman Kanagala*, Martine Ceberio, Thompson Sarkodie-Gyan, Vladik Kreinovich, and Roberto Araiza*, "Identification of Human Gait in Neuro-Rehabilitation: Towards Efficient Algorithms", in the Proceedings of the **24th Southern Biomedical Engineering Conference**, Eds. H. Nazeran, M. Goldman, and R. Schoephoerster, Medical and Engineering Publishers, pp. 153–156, 2008.

C14 Stefano Bistarelli, Martine Ceberio, Eric Freudenthal, and Christian Servin*, "An Optimization Approach to the Cascade Vulnerability Problem using Soft Constraints", in the proceedings of **NAFIPS 2007, the North American Fuzzy Information Processing Society**.

C16 Martine Ceberio, Richard Coy*, François Modave, "Multi-criteria Decision Making for Assisted Design", in the proceedings of **IPMU'06, Information Processing and Management of Uncertainty in Knowledge-based Systems**, pp. 1567–1574, 2006.

C23 Martine Ceberio and Richard Coy*, "Enhancement of Parameter Estimation using Flexible Constraints: an Application to Shock-response Study", in the Proceedings of **"Algorithmic Mathematics and Computer Science" (AMCS'05)**, 2005.

C24 François Modave, Martine Ceberio, Xiaojing Wang*, Olga Garay*, R. Ramirez*, and R. Tejada*, "Comparison of Computer Attacks: an Application of Interval-based Fuzzy Integration", in the Proceedings of **NAFIPS'05, the North American Fuzzy Information Processing Society**, 2005.

C25 Martine Ceberio, François Modave, and Xiaojing Wang*, "Comparing Attacks: an Approach Based on Interval Computations and Fuzzy Integration", in the Proceedings of **FuzzIEEE'05, the IEEE International Conference on Fuzzy Systems**, 2005.

W3 Paulo Pinheiro Da Silva, Martine Ceberio, Christian Servin*, Vladik Kreinovich, "Propagation and Provenance of Probabilistic and Interval Uncertainty in Cyberinfrastructure-Related Data Processing", in the proceedings of **the NSF Workshop on Reliable Engineering Computing, REC'08**.

A3 Shubhra Datta*, Martine Ceberio, Mario Bencomo*, and George Moreno*, "On the Practicality of Constraint-Based Program Verification", in the proceedings of **SCAN'10**, 2010.

A6 Paden Portillo*, Martine Ceberio, Vladik Kreinovich, "Towards an Efficient Bisection of Ellipsoids", in the book of abstracts of **CoProD'10**, 2010.

4.4 Presentations by students involved in research in national and international conferences

Of the articles listed in Subsection 4.3, the following were presented at conferences by one of the student authors: C3, C5, C6, C8, C9, C14, C23.

Besides the presentation of the articles listed above, I catch every opportunity to put my students in the situation of presenting their work. For instance, I have my students present their work as often as practical at the regional UTEP-NMSU workshop. I also expose them to the national and international research by having them write reviews of articles and by involving them in the logistics of the conferences I organize: for instance, 4 of my students were helpers at NAFIPS'2011, and one of my PhD student represented me as an organizer for a workshop at CP-AI-OR'09 when I was on maternity leave.

5 Appendix: List of Supporting Documents

5.1 Articles

- **Journal articles**

  J2 Martine Ceberio and Vladik Kreinovich, "Computing with Tensors: Potential Applications of Physics-Motivated Mathematics to Computer Science", Journal of Uncertain Systems, 2010, Vol. 4, No. 3.

  J11 Frederic Benhamou, Martine Ceberio, Philippe Codognet, Hiroshi Hosobe, Christophe Jermann, Ken Satoh, Kasunori Ueda, "Franco-Japanese Research Collaboration in Constraint Programming, R&D Project Report", in Progress in Informatics, no 3, pp. 59-65, 2006.

  J12 Chandra S. Pedamallu, Linet Ozdamar, Martine Ceberio, "Efficient Interval Partitioning – Local Search Collaboration for Constraint Satisfaction", in the Journal on Computers and Operations Research, 2006.

- **Book chapters**

  Ch2 Martine Ceberio, Tanja Magoc, Vladik Kreinovich, and FrancÌ§ois Modave, "Risk Management in Investment Portfolios: The Use Of Fuzzy Measures, Fuzzy Integrals and Constraint Programming", Aboul-Ella Hassanien and Ajith Abraham (Eds), Foundations on Computational Intelligence, in Studies in Computational Intelligence, Springer Verlag, Vol. 202/2009, pp 133-173, 2009.

  Ch4 Martine Ceberio and Francois Modave, "Interval-based Multicriteria Decision Making", in Modern Information Processing: From Theory to Applications, edited by B. Bouchon-Meunier, G. Coletti, R. R. Yager (Eds), Elsevier Mathematics, pp. 281–294, 2006.

- **Articles in conference proceedings**

  C3 Xiaojing Wang, Jeremy Cummins, and Martine Ceberio, "The Bees Algorithm to Extract Fuzzy Measures from Sample Data", best student paper award, Proceedings of NAFIPS 2011, the North American Fuzzy Information Processing Society, 2011. Best Student Paper Award (first place).

  C9 Tanja Magoc, Martine Ceberio, and FrancÌ§ois Modave, "Interval-based Multi-Criteria Decision Making: Strategies to Order Intervals", in the proceedings of NAFIPS 2008, the North American Fuzzy Information Processing Society, 2008.

  C14 Stefano Bistarelli, Martine Ceberio, Eric Freudenthal, and Christian Servin, "An Optimization Approach to the Cascade Vulnerability Problem using Soft Constraints", in the proceedings of NAFIPS 2007, the North American Fuzzy Information Processing Society.

  C22 Martine Ceberio, Ken Satoh, and Hiroshi Hosobe, "Speculative Constraint Processing with Multi-Agent Belief Revision", in the proceedings of CLIMA IV, Computational Logic in Multi-agent Systems, 2005.

  C27 Martine Ceberio and FrancÌ§ois Modave, "An Interval-valued, 2-additive Choquet Integral for Multicriteria Decision Making", in the proceedings of IPMU 2004, Information Processing and Management of Uncertainty in Knowledge-based Systems, 2004.

5.2 Proposals

- **Funded**

  1. **PI** (NSF CCF 0953339) CAREER: Symbolic-Numeric Constraint-Based Solutions for Real-World Scientific Problems. Duration: 01/01/2010 to 12/31/2014. Amount: $564,650.
  2. **PI** (NSF CCF 0839052) Constraint Programming and Decision Making Workshop, CoProD'08. Duration: 08/15/2008 to 07/31/2010. Amount: $5,941.

- **Rejected**

  1. **Co-PI** (NIH-RO) Automated Diagnosis and Therapy in Human Gait Using the Methods of Computational Intelligence. Duration: 2006 - 2011. Amount: $2.5M.

5.3 Other supporting documents

- Email from Siemens regarding their geometric solvers to include on constraintsolving.com
- Website: http://www.constraintsolving.com.
- Website of CoProD: http://coprod.constraintsolving.com.