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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). 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

1This 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 abnormal 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 constraint-solving.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 inter-
national 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-


J3 Martine Ceberio and Vladik Kreinovich, “Diagonalization is also practically useful: a

J4 Omar Ochoa*, Martine Ceberio, and Vladik Kreinovich, “How to Describe Spatial Reso-
lution: An Approach Similar to the Central Limit Theorem”, Applied Mathematical

J5 Martine Ceberio, Vladik Kreinovich, Gunter Mayer, “For Complex Intervals, Exact
Range Computation Is NP-Hard Even for Single Use Expressions (Even for the Prod-

J6 Daniel Berleant, Martine Ceberio, Gang Xiang*, Vladik Kreinovich, “Towards Adding
Probabilities and Correlations to Interval Computations”, International Journal of

J7 Gang Xiang*, Martine Ceberio, Vladik Kreinovich, “Computing Population Variance
and Entropy under Interval Uncertainty: Linear Time Algorithms”, Reliable Com-

J8 Martine Ceberio, Scott Ferson, Vladik Kreinovich, Sanjeev Chopra*, Gang Xiang*,
Adrian Murguia*, and Jorge Santillan*, “How To Take Into Account Dependence Be-
tween the Inputs: From Interval Computations to Constraint-Related Set Computations,


1.5 List of articles in conference proceedings


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.


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.


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.


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.


1.6 Chapters in Scholarly Books and Monographs


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


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.


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.


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.


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


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.


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.


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.


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).

And supplements:


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\(^3\)NII: National Institute of Informatics, Tokyo, Japan.

\(^4\)LINA: Laboratoire d’Informatique de Nantes Atlantique, Nantes, France.

### 2.2 Pending Grants


### 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.


5. **Supporting faculty** (NSF IGERT 1037451) IGERT Multiphysics Training and Education Program (µTEP). Duration: 2010-2015.


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


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


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**.


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.
Appendix: List of Supporting Documents

5.1 Articles

- Journal articles


- Book chapters


- Articles in conference proceedings


5.2 Proposals

- **Funded**


- **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
