Annual Report for Period:01/2011 - 12/2011
Submitted on: 12/03/2011
Principal Investigator: Ceberio, Martine C.
Award ID: 0953339
Organization: U of Texas El Paso
Submitted By:
Ceberio, Martine - Principal Investigator
Title:
CAREER: Symbolic-Numeric Constraint-Based Solutions for Real-World Scientific Problems

Project Participants

Senior Personnel

Name: Ceberio, Martine
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Graduate Student

Name: Portillo, Paden
Worked for more than 160 Hours: Yes
Contribution to Project:
Paden Portillo has worked on the project since Spring 2010. His work has consisted in exploring the use of circular interval arithmetic for constraint solving. He also contributed to the work of the project dedicated to optimization: in collaboration with Xiaojing Wang, he designed strategies of interaction of local and global solvers.

Name: Del Hoyo, Christian
Worked for more than 160 Hours: No
Contribution to Project:

Name: Datta, Shubhra
Worked for more than 160 Hours: No
Contribution to Project:
Shubhra Datta is a Master's student, part of the team of students working with the PI. She works on using constraints for program verification and from that point of view considers the performance of solvers, with respect to the symbolic shape of the constraints but also with respect to their number and number of variables.

Name: Wang, Xiaojing
Worked for more than 160 Hours: No
Contribution to Project:
Xiaojing Wang is a PhD student. She works on the specific problem of Fuzzy Measure Extraction for Multi-Criteria Decision Making. In the context of her work, she contributes in the study of the interaction between local and global solvers.

Name: Garcia Contreras, Angel
Worked for more than 160 Hours: Yes
Contribution to Project:
Angel joined my research group in summer 2011. He has since then been working on speculative algorithms for constraints and optimization. Given the short time he has been in my research team, he has shown a lot of devotion to the research project.
He also was brought on-board for one of our educational projects with one of the high-schools of El Paso and has shown that he is very reliable and dedicated.

Undergraduate Student

Name: Moreno, George

Worked for more than 160 Hours: Yes

Contribution to Project:

George participated in the project from January to June 2010. His work consisted in a literature review on constraint solvers: he was assigned to working on the solver and explore the best designs in C++ and Matlab.

Name: Bencomo, Mario

Worked for more than 160 Hours: Yes

Contribution to Project:

Mario Bencomo has worked on the project since Spring (with the exception of Summer during which he was an intern at UCLA). He has been working in the area of global constraints. He is currently working on rectangular systems of inequalities with no bounds on variables' values and exploring the possibilities for row reduction as opposed to solving the given system in its original version.
Mario also contributed to the effort of the team in outreach activities.

Name: Gutierrez, Luis

Worked for more than 160 Hours: Yes

Contribution to Project:

Luis Martinez has been working on the project since late Spring 2010. He has worked with Mario Bencomo (Mario being the lead on this topic) on global constraints. Luis also helped in outreach activities.

Name: Chacon, Marisol

Worked for more than 160 Hours: Yes

Contribution to Project:

Marisol just joined the group a month ago. She has started to work on the strategies of interaction of global and local solvers, so speed solving processes. At this point, she is barely starting experiments.

Name: Martinez, Luis

Worked for more than 160 Hours: No

Contribution to Project:

Luis Martinez joined the group in late Spring 2010. Due to his commitment to a full-time job outside of school, he has not been able to focus on any specific topic at that time. However, he has helped a lot with outreach activities.

Name: Cummins, Jeremy

Worked for more than 160 Hours: Yes

Contribution to Project:

Jeremy was an undergraduate student recruited by Dr. Olac Fuentes at UTEP in Summer 2010 to participate in his REU site experience.
Jeremy worked with Dr. Ceberio's team on an hybrid optimization solver that was applied to fuzzy measure extraction.
He was fully supported by Dr. Fuentes' REU grant.

Name: Watke, Michael

Worked for more than 160 Hours: No

Contribution to Project:

Michael worked with me for 2 months in summer 2011. He was an intern, as part of an REU site summer program whose PI is Dr. Olac Fuentes at UTEP.
He addressed a problem related to software engineering (generation of minimal pairwise-covering test suites) using constraints and optimization. We made significant progress in the area but yet have to write and publish on the topic.
He presented his work in a poster-presentation session at UTEP at the end of summer.

Name: Bixler, Robert

Worked for more than 160 Hours: No

Contribution to Project:

Michael worked with me for 2 months in summer 2011. He was an intern, as part of an REU site summer program whose PI is Dr. Olac Fuentes at UTEP.
Although he was not as successful as Michael Watke, he was able to implement a framework for solving constraint and

optimization with speculation, which Angel took over the rest of the summer.

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

El Paso Community College, Transmountain

Dr. Alvarez at EPCC Transmountain in El Paso is a faculty of the Community College who works with Early College High School students. She invited me during the spring 2010 semester to give a talk to these students and later on offered my students and myself the opportunity to propose these students a summer research project, in 2010, as part of her Department of Education MSEIP grant.

We accepted their offer as it constituted a great opportunity for outreach and transfer of our research topics and findings to young students. My students (Luis Gutierrez and Luis Martinez in summer 2010, Luis Gutierrez and Christian del Hoyo in summer 2011) and I took part of the 'faculty' in charge of this summer institute in 2010 and 2011.

I supervised and my students helped in coordinating this research project over summer 2010. Both years, we offered projects that, although not focused on constraints or optimization, offered us ways to expose the high-school students to our research. Both years, our team of high-school students won prizes at the end-of-summer competition (2nd place in 2010, 1st and 3rd place in 2011).

Although this year was the last year of the MSEIP grant program at EPCC, we expect to keep this collaboration open in hope of participating in the same type of activity next year. I am seeking funding for establishing a similar program more centered around my research topic with applications to bio-medical engineering.

Harmony Science Academy of El Paso

The collaboration with Harmony Science Academy of El Paso is twofold:

1) In 2010, I started a collaboration with the math department of the Harmony School of Innovation (same group of schools, different campuses) in order to design the integration of computer science, problem-solving oriented material that my students and I could bring into their classrooms, to get students excited about computer science. We also expect, through surveys, to be able to learn about what triggers the turning-on or off for computer science studies in younger students (female and minorities in particular). The change in management in this school has delayed the progress of this project. I hope to be able to concretely start intervening in their classrooms in spring 2012.

2) Two female high-school students from HSA were interns in my lab in Summer 2010 and remained members of my research group until summer 2011. These two students learned a lot in our lab and are developing projects (for local and regional fairs) through which we try to teach them as much problem-solving skills and constraint solving as possible.
In 2011, I invited them, as well as their classmates to my annual workshop, CoProD, which was held at UTEP. They were this way exposed to latest research results in constraints and decision making.
I acted as a mentor for their team in the first lego league robotics competition in 2010 and I am now (2011) their mentor for the MIT robotics zero gravity challenge.

Chapin High School, El Paso

I have been in contact with the Engineering Magnet coordinator at Chapin High School, Ms Corina Favela. Meetings have been organized to find ways of interacting.

I have been involved in judging and helping their students for science and engineering presentations in spring 2011. I also participated in planning meetings but there has not been further follow-ups at this point.

Loretto Academy

Loretto Academy is a catholic school of El Paso. I have worked with the high-school component of it only: their high-school is a girls-only school.

I targeted this institution because of my previous positive contacts with them, but most importantly because it is a girls-only institution and I am very interested in gender issues / broadening participation in computing (this is my second education objective).

Project 1:
Over the fall 2011, I have, helped by my students Christian del Hoyo, Luis Gutierrez, and Angel Garcia, started a project with their French teacher: the senior students have to design a video (in French) presenting news and we supervise them so that the video is implemented in the scratch language. The reason for picking this project is that our assumption (which turned out to be correct) is that these students are likely not to be much inclined towards computing disciplines (at least less than the students taking their AP CS course) and in an effort to broaden participation in computing, we decided to target this kind of students to change their views of computer science. So far the on-going project has been very successful and the students are to present their projects in front of the principal by the end of the semester.
Based on a large student demand, it is likely that we will be conducting similar projects in the future again. This will help us gather more significant data over time.

Project 2:
I have been in contact with their Math teacher since 2010. We should have started this fall 2011 semester a series of interventions of my students and I in her classroom. However, the load of work generated by the French project was not compatible with another project in this school so we decided to postpone to spring 2012.

Other Collaborators or Contacts

* Julia Bader, from the Statistical Lab in the Math Department at UTEP. Julia helps me in designing surveys to be taken by high-school students when we interact with them, so as to gather data about the impact of our presentations / material.

* Rasmus Bro, from the Chemometrics Group, Dept. of Food Science
University of Copenhagen.
Since meeting him at an AIM workshop on Optimization and tensor decomposition in spring 2010, my students and I have been working on a problem of his: rectangular matrix to be reduced. We contacted him once we obtained good results about constraint reduction in summer 2010. We have not had further collaboration.

* Suvrajeet Sen, from Ohio State University:
We are both interested in decision making. He is a specialist in stochastic optimization and has many problems related to reliability, guarantee of results. My department invited him earlier this year 2011 and we discussed about possible contributions of my work on constraints and interval computations to his work. I am now member of his group on unstructured data.

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

* RESEARCH:
Up to now (mid-November 2010), the team (the above-mentioned students and myself) has put its efforts in the following areas: 1) improving the scalability of constraint solvers (through the study of global constraints, other arithmetics for example), 2) interaction of local and global solvers; 3) design of a solver.

1) Global Constraints:
We explored the possibility of designing global constraints for constraints with continuous variables. In doing so, we got interested in large rectangular linear systems of equations or inequalities. We addressed inequalities first. At this point, we were able to find ways to reduce the size of the problem. We are about to start a comparative study of our method against traditional interval solving techniques.
Some of the methods we proposed involve approximations: we are currently conducting a theoretical study and exploring algorithmic ways to quantify the error and/or get back to the original solution set at a lower cost than if we were to solve the initial problem without approximation of course.

2) Different interval arithmetics:
We studied how reasonable disk intervals would be suited for constraint solvers. We focused on 2D to start and designed ways of checking whether a constraint is satisfied within a disk. Although we achieved some results, it seems that we might not keep following this exact direction but rather orient our research with disks to ways to grasp basins in optimization problems and use this information as an indication of the location of minima. This is one of the research directions for the follow-up on this topics during Year 2 of this project.

3) Interaction of Local/Global Solvers:
In the aim of eventually being able to solve large systems of constraints, we explored the possibility of relieving the global search using local solvers. Although the idea is not new, what we propose here is to study strategies of interaction, in other words, to find the best interaction: this would eventually be achieved in what is also called adaptive interaction since one interaction schema cannot fit all problems.
We conducted this research in the context of a specific problem: fuzzy measure extraction. We are currently finalizing the analysis of the first of our experiments and will submit it soon for publication. We will then conduct more extensive experiments to lay the foundation of adaptive interaction.

4) Solver:
One of the goals of this project is to make constraint solving techniques more widely available to domain scientists. For this reason, we decided to implement our findings both in C++ and Matlab. The first half of this year was spent in training students to both languages. We are now starting to make progress in the development of the C++ library. Regarding Matlab, part of our findings (about global constraints) is implemented in Matlab. We will also likely integrate IntLab. However, we plan to also explore the avenue of using Mathematica or Maple. Our preliminary decision will be made by early 2011.

** PRESENTATIONS:
We have presented our work at different venues: a regional symposia (the two biannual UTEP-NMSU Workshops), at SCAN'2010, at Sandia National Lab, at the ICIS workshop on Optimization and Energy Systems, and one of our results on circular interval arithmetic should be soon submitted to the extended paper proceedings of CoProD'09-10, to be published in a special issue of Advances in Soft and Intelligent Computing, by Springer.

** EDUCATION:
Our activities related to integrating our findings or research topic into education has been of two main kinds: 1) outreach activities to schools of the El Paso area; 2) providing class project / lab topics and lectures to courses in computer science.

1) Outreach:
We have participated in ad-hoc outreach activities, such as an open house at UTEP, a career fair, a summer research project program, an REU site project, hosting high-school interns within UTEP's Nexus program. We are already also expected to participate in various activities (presentations at High School events for instance) in the spring 2011.
These activities allowed us some time, while still being active in outreach activities, to establish more connections and a more perennial plan of action.
In particular, it is expected that we will participate in the summer research project program of El Paso Community College for Early College High School students next summer. We will continue hosting high-school interns as well, and from different schools as well.

In parallel, we have been establishing closer contacts with teachers of the schools that were willing to work with us in integrating part of our material or contribution to their classroom (3 schools are strong collaborators already: Loretto Academy, Chapin High School, and Harmony Science Academy). We expect to have our first intervention in class by the end of 2010 or early 2011 depending on the teachers' schedule.

2) Integrating our research topics in CS courses:
During spring 2010, projects with a strong constraint or optimization components were proposed at the undergraduate level (in the artificial intelligence class, taught by Dr. Magoc) and graduate level (in the logical foundations of computer science class, taught by myself). More class projects originating from topics considered in my team (hybrid solvers for instance) were proposed this semester (for the graduate course on advanced algorithms, taught by myself).
I am currently compiling and finalizing some more class projects or lab topics to be disseminated during the spring semester when AI is taught again, as well as in CS3: Data structures and algorithms.
Besides class projects, I also gave two lectures for the AI course during spring: this lecture emphasized topics that are our focus in the research team.

Findings:

Findings:

1) global constraints:
Year 1: We designed ways to ease the solving process of large rectangular matrices. We are still in the process of integrating this is a general constraint solver / optimization.
Year 2: We designed and finished the implementation of a new constraint reducer for systems of linear inequalities, that is based on a similar search space exploration as for constraint solving. We expect this new algorithm to be able to provide more manageable constraint solution sets as an alternative to interval solutions.

2) disk intervals for constraints:
Year 1: We designed ways of looking at constraints on ellipsoids, and for that matter of bisecting them, so as to converge to solutions.

3) interaction of local/global solvers:
Year 1: We were able to study the improvement brought by making a local solver and a complete constraint solver interact. We are now working on quantifying the improvement on the scalability of the process.
Year 2: We designed a global optimization solver that focuses primarily on the dimension of the objective function value rather than on the n-dimensional original search space. Although we have not yet conducted extensive scalability analysis, we were able to observe that this algorithm is able to handle efficiently larger problems that the hybrid solver designed on Year 1, and is competitive or better than results provided on traditional optimization benchmarks.

4) Constraint solving platform:
Year 2: We finished the implementation of our first prototype platform for constraint solving.

Training and Development:
The team composed of the involved students (as documented in the file attached at the end of this report) and the PI have worked very closely over Years 1 and 2 of the project.

Year 1: The reasonable number of core students allowed to create enough expertise (or experience at first) for more senior students to be able to take on the role of mentors: across different levels of high-school students, UG, G, PhD candidate. Although the team was mostly composed of undergraduate students in 2010 (more UG than G), it is expected that the ratio will change in 2011, allowing for even more mentoring.

Although I did not gather any data on the benefit of mentoring, I could observe that students (both mentors and mentees) tend to perform better, feel like they belong more to the group, and tend to stay longer in the group as well. For instance, the two female high-school students who have been interns in my group since summer were the first two students who do not opt out of a computer science internship program at UTEP: they felt that they were well integrated to the group and that there work with us was really benefiting them.

Besides peer-mentoring, I also encourage my students to attend conferences. One of them attended both AAAI and the Grace Hopper Conference. She learned a lot from these. As the group of students will grow, I will encourage my students to keep attending such meetings as much as practical.

As far as I am concerned, I was fortunate enough to attend an AIM workshop on Optimization and Tensor Decomposition in March/April 2010. This workshop allowed me to better understand the large scale optimization faced in the area of tensor decomposition and provided me with an application case that my students and I considered as a candidate for a global constraint. We have since then been working on it. My participation in this workshop led to my participation in the ICIS workshop on Optimization and Energy Systems in summer 2010: this workshop broadened my views even more about large scale optimization systems, including for most, black box systems. Attending this workshop also allowed me to significantly network and I hope that by early next year, some of these contacts will results in formal collaboration (in the area of optimization and constraints).

Year 2: Unfortunately, the team lost a few members over Year 2 (due to change in institution, or personal reasons preventing the students to stay in El Paso): this loss resulted in a decrease in expertise. However, I must report that the synergy of the team allowed for a reasonable transition through the loss of students and the integration of new ones, even temporarily as was the case for the summer undergraduate students my team hosted.

My current team is very solid, although still on the low side regarding its size. For lack of a large representation of PhD students at this time, I am spending more time mentoring my students, taking on some of the mentoring PhD students could otherwise offer. Over summer, due to the team's activities with research projects for high-school students, as well as in the fall with the projects we had with Loretto academy, my students have the opportunity to practice their mentoring skills. We have group meetings during which I actually discuss with them some of the key mentoring skills and answer their questions regarding their supervising younger students.

Besides, I significantly involved my students in the organization of NAFIPS and CoProD'11 which I co-chaired and chaired, respectively. This experience allowed them to start conversations with researchers in our area, as well as to practice some professional skills, such as accountability, positive interdependence, etc.

I have also myself been able to participate in training: I took part in an Affinity Research Group Model Training Workshop, held in Puerto Rico in August 2011. This training was very helpful: it helped me further develop my mentoring skills and nurture even more the culture and synergy of my team.

On a side note, I was elected a member of the board of directors of NAFIPS (the North American Fuzzy Information Processing Society) and recently accepted the invitation to join the board of editors of Springer's Journal of Soft Computing. These two opportunities have and will broaden my views of the scientific governance.

Outreach Activities:

* OUTREACH TO SCHOOLS:
The team has been working with 3 middle / high schools of El Paso: Harmony Science Academy (2 campuses, MS and HS), Chapin High School (MS and HS), Loretto Academy (MS and HS: but working with HS only).
We also participate every year in the career fair of an elementary school of El Paso (Mitzi Bond Elementary school) and of Loretto as well (more information on the activities attached file as well as on the file attached at the end of this report).

* NEXUS PROGRAM:
Since summer 2010, we have been involved in UTEP's NEXUS program (http://engineering.utep.edu/plaza/Nexus/index.html). We hosted two female students from Harmony Science Academy in summer 2010 and 3 in spring 2011.

* EARLY COLLEGE HIGH-SCHOOL PROGRAM:
I was invited to give a seminar to the ECHS students in April 2010. As a result of my presentation and the interest of students, I was invited to propose and mentor a summer research project for these ECHS in summer 2010. Two students participated in our research project and won second place in the end-of-summer ECHS project competition. In summer 2011, we participated again in this program.
I was able to give a lecture to all participating students about my research. My research students and I also supervised two research projects, gathering a total of 5 students. One of these projects won 1st place, the other 3rd place at the end-of-summer competition.

* CoProD WORKSHOP:
I annually organize a CoProD workshop (coprod.constraintsolving.com).
In 2010, the first time I was planning to hold it outside of El Paso (and abroad for that matter), I had to cancel it: I had originally planned for a short program (due to logistics issues) and when a major speaker canceled, I decided to cancel the whole workshop.
Nevertheless, I considered all submissions to be submitted to the post-workshop proceedings to form a special issue of the Springer series in Advances in Soft and Intelligent Computing. The deadline for submissions is upcoming soon (end of 2010).
In 2011, CoProD was successfully held in March 2011 at the University of Texas at El Paso, gathering around 40 participants. It was held right before NAFIPS'12, also held in El Paso. I was the general co-chair and co-program chair of NAFIPS as well.
CoProD'12's organization is underway: CoProD'12 will be held in Novosibirsk, Russia.

Journal Publications

Books or Other One-time Publications

Shubhra Datta, Mario Bencomo, George Moreno, Martine Ceberio, "On the Practicality of Constraint-Based Verification of Software", (2010). Proceedings, Book of abstracts, Published
Bibliography: In the book of abstracts of SCAN 2010, the 14th GAMM-IMACS International Symposium on Scientific Computing, Computer Arithmetic and Validated Numerics. ENS de Lyon, France, Septemb

Xiaojing Wang, Jeremy Cummins, Martine Ceberio, "The Bees Algorithm to Extract Fuzzy Measures for Sample Data", (2011). Book of proceedings, Published
Bibliography: NAFIPS'2011, the Annual Conference of the North American Fuzzy Information Processing Society

Paden Portillo, Martine Ceberio, Vladik Kreinovich, "Towards an Efficient Bisection of Ellipsoids
", (2011). Book, Accepted
Bibliography: In the proceedings of the International Test and Evaluation Association Conference

Mario Bencomo, Luis Gutierrez, Martine Ceberio, "Modified Fourier-Motzkin Elimination Algorithm for Reduction in Systems of Linear Inequalities
", (2011). Book, Accepted
Bibliography: In the proceedings of the International Test and Evaluation Association Conference

Vladik Kreinovich, Christelle Jacob, Didier Dubois,
Janette Cardoso, Martine Ceberio, and Ildar Batyrshin,, "Estimating Probability of Failure of a Complex System Based on Inexact Information about Subsystems and Components, with Potential Applications to Aircraft Maintenance", (2011). Conference Proceedings, Published
Editor(s): I. Batyrshin and G. Sidorov (eds.)
Collection: Springer Lecture Notes in Artificial Intelligence
Bibliography: Proceedings of the 10th Mexican International Conference on Artificial Intelligence MICAI'2011, Puebla, Mexico, November 26 - December 4, 2011, Springer Lecture Notes in Artificial

Martine Ceberio and Vladik Kreinovich,, "No-Free-Lunch Result for Interval and Fuzzy Computing: When Bounds Are Unusually Good, Their Computation is Unusually Slow", (2011). Conference Proceedings, Published
Editor(s): I. Batyrshin and G. Sidorov
Collection: Springer Lecture Notes in Artificial Intelligence
Bibliography: Proceedings of the 10th Mexican International Conference on Artificial Intelligence MICAI'2011, Puebla, Mexico, November 26 - December 4, 2011, Springer Lecture Notes in Artificial

Olga Kosheleva, Martine Ceberio, and Vladik Kreinovich, "Adding Constraints -- A (Seemingly Counterintuitive but) Useful Heuristic in Solving Difficult Problems", (2011). Workshop book of abstracts, Published
Bibliography: Proceedings of the Fourth International Workshop on Constraint Programming and Decision Making CoProD'11, El Paso, Texas, March 17, 2011.

Jan Sliwka, Luc Jaulin, Martine Ceberio, and Vladik Kreinovich, "Processing Interval Sensor Data in the Presence of Outliers, with Potential Applications to Localizing Underwater Robots", (2011). Conference Proceedings, Published
Bibliography: Proceedings of the 2011 IEEE International Conference on Systems, Man, and Cybernetics SMC'2011, Anchorage, Alaska, October 9-12, 2011, pp. 2330-2337.

Uram Anibal Sosa Aguirre, Martine Ceberio, and Vladik Kreinovich, "Why Curvature in L-Curve: Combining Soft Constraints", (2011). Workshop book of abstracts, Published
Bibliography: Proceedings of the Fourth International Workshop on Constraint Programming and Decision Making CoProD'11, El Paso, Texas, March 17, 2011.

Aline Jaimes, Craig Tweedie, Vladik Kreinovich, and Martine Ceberio, "Scale-Invariant Approach to Multi-Criterion Optimization under Uncertainty, with Applications to Optimal Sensor Placement, in Particular, to Sensor Placement in Environmental Research", (2011). Journal article, Accepted
Bibliography: International Journal of Reliability and Safety

Xiaojing Wang, Jeremy Cumming, Martine Ceberio, "An Adaptive Hybrid Algorithm to Extract Fuzzy Measures for Sample Data
", (2012). Journal article, Ready for submission
Bibliography: International Journal of Multi-Criteria Decision Making

Xiaojing Wang, Martine Ceberio, Shamsnaz Virani, "Fuzzy Measure Extraction for Software Quality Assessment as a Multi-Criteri
", (2012). Conference Proceedings, Submitted
Bibliography: International Conference on Software Engineering

Web/Internet Site

URL(s):
http://cr2g.constraintsolving.com
Description:
This website is the website of CR2G, the research team of the PI. This website provides information and gives access to the activities of the team regarding the current project.

Other Specific Products

Contributions

Contributions within Discipline:
Year 1: The work done during the first year of this project is going in the direction of significantly impacting the area by proposing ways of scaling constraint solvers while retaining nice properties, such as certificates of globality / completeness that are of great importance in constraint-based verification of software for instance as well as in global optimization.

As this point in the project's duration, we have not made these significant contributions yet but we expect to see solid contributions, completed with complementary experimental results, to be ready some time during the second year of the project.

Year 2: We have reached a point, during year 2, when the team has now designed several solvers (hybrid, all intervals, local, etc.) that have shown improvement in one area of another.
In particular, the optimization solvers that we have developed have successively improved the quality of solutions in the case of fuzzy measure extraction. They made it possible to apply multi-criteria decision-making models (based on fuzzy measures) to software quality assessment.
In the area of purely constraint solving, we have finished a prototype platform that will allow constraint solvers to be plugged to our intelligent solving system.
We will now start to work on releasing these tools and see how engineers find them usable.

Contributions to Other Disciplines:
Constraint solvers and optimization are not so much important to computer scientists as they are for domain scientists.

For instance, the work that we have been carrying out in the area of global constraints was primarily aimed towards tensor decomposition: we obtained the original problem from and we have since been in contact with Rasmus Bro, who is a domain scientist in the Department of Food Science at the University of Copenhagen.

We also applied our work on a hybrid solver for fuzzy measure extraction to software quality assessment. Our new algorithm for global optimization and our parallel work on decision making have raised the interest of different communities on the UTEP campus, including people from health sciences, psychology, and education, and a new group of interest was created.

Besides the contact and applications that we have, we also organize CoProD once a year with this exact aim of impacting other disciplines.

Contributions to Human Resource Development:
My research group, CR2G -- cr2g.constraintsolving.com, originally grew as an effect of receiving this NSF grant. Although we deplored loss of students during Year 2, we can still report that the group has grown overall: other students have expressed interest in CR2G due to the activity of the project, although they might not be directly involved in this project.

By the end of Year 1, three students in CR2G were in the group because of the project and we were expecting to recruit a female PhD student in spring of Year 2. This student eventually and rapidly dropped, and with another female student leaving after her graduation, I now have only one female student in my group. I am working on inviting more women to my group as I am interested in gender issues in computing.

from a broader point of view, we also hope that our outreach work helps changing girls' minds about career in computing, but there is no data to support this claim at this point in the project.

Contributions to Resources for Research and Education:

My team and I also maintain a website: constraintsolving.com, which is a 'research community website' in the sense that it aims at informing about constraints. Through this work, we hope to help people learn more and better about this area.

Contributions Beyond Science and Engineering:

Conference Proceedings

Special Requirements

Special reporting requirements: None
Change in Objectives or Scope: None
Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Any Journal
Any Product
Contributions: To Any Beyond Science and Engineering
Any Conference

NSF CAREER: Symbolic-Numeric Constraint-Based Solutions for Real-World Scientific Problems

REPORT for Year 2 (2011) of the project Activities and Findings

Award number: CCF 0953339
01/01/2011 through 12/31/2011
Program Director: Petros Drineas

PI: Martine Ceberio
Computer Science Department
University of Texas at El Paso
mceberio utep.edu

1 Summary of context and expected activities

Numerical constraint solving (NCS) techniques have proven to be efficient to solve real problems ranging from electronic circuit to aircraft design. Yet they are under-utilized. The lack of user support of the solvers can partly explain this, but most importantly NCS techniques have iso- lated themselves into a jargon (constraints) and a schema (propagation/reduction) that disconnect them, respectively, from real problems and real needs (e.g., scalability, flexibility, and distribu- tivity). The goal of this career plan is to make NCS 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.

During Year 2 of this project, the team was to pursue their effort on Research Objective **RO1:** To open NCS to novel techniques, improving scalability. The definition of several global constraints was to be completed and research was to begin on **RO2:** To assist users facing over-constrained problems. New methods based on the topology of the search space, in terms of satisfaction of the constraints, will be designed to provide users with alternative solutions. The team was to start the integration of the project's advances into a Matlab toolbox at that time. In the summer of Y2, the PI was to develop course material for NCS distributed systems to be integrated into her Constraint-Based Problem Solving course.

Over the duration of the project, the results of the research objectives are to be fed into the effort to meet the team's education objectives: **EO1: to enhance the problem-solving skills** and interest in advanced studies for middle-school to undergraduate students; and **EO2: to enhance the participation of women** and Hispanics in computing.

This document reports the activities and findings of Dr. Ceberio's team during Year 2

of her NSF CAREER project, titled: Symbolic-Numeric Constraint-Based Solutions for Real-World Scientific Problems.

In the rest of this report, we will start by presenting Dr. Ceberio's team over Year 2 in Section 2. The research activities and findings will be reported in Section 3 and we will draw plans for Year 3. Section 4 reports on the education / outreach activities carried out during Year 2, discusses how they align with the objectives of this project, and presents the forecoming activities planned for Year 3.

2 Presentation of the team working on this project

Over the course of Year 2, several students, at the undergraduate and graduate levels, were involved at different levels of commitment in the project. They are listed hereafter:

PhD students:

- Aziza Aouhassi, PhD student: part of the team in spring 2011. She left the program after one semester.
- Xiaojing Wang, PhD student: part of the team all year. She is expected to graduate in summer 2012.

Master's students:

- Mario Bencomo, graduate student: part of the team in spring 2011. He left UTEP's program to join Rice University's PhD program in Mathematical and Computational Sciences.
- Shubhra Datta, graduate student: part of the team until September 2011 when she graduated with an MS in Computer Science.
- Christian Del Hoyo, graduate student: part of the team all year. He is expected to graduate in summer 2012.
- Angel Garcia, graduate student: part of the team since summer 2011.
- Paden Portillo, graduate student: part of the team in early spring 2011. He left the team due to personal reasons.

Undergraduate students:

- Robert Bixler, undergraduate student / REU student supported by the REU site summer program of Dr. Fuentes at UTEP: part of the team in summer 2011.
- Luis Carlos Gutierrez, undergraduate student: part of the team all year.
- Michael Watke, undergraduate student / REU student supported by the REU site summer program of Dr. Fuentes at UTEP: part of the team in summer 2011.

	Spring	Summer	Fall	2010
PhD students	2	1	1	
Aziza Aouhassi	X			No
Xiaojing Wang	X	X	X	Yes
Master's students	3.5	3	2	
Mario Bencomo	X			Yes, as UG
Shubhra Datta	X	X		Yes
Christian Del Hoyo	X	X	X	Yes
Angel Garcia		X	X	No
Paden Portillo	Half			Yes, as UG
Undergraduate students	1	3	1	
Robert Bixler		X		No
Luis Carlos Gutierrez	X	X	X	Yes
Michael Watke		X		No

Table 1: Summary of student participation in project team during Year 2, along with information regarding their participation or not in previous year.

3 Research activities and directions

During Year 2 of this project, the above team continued the work initiated during Year 1 on Research Objective RO1. Most of the work carried out to meet RO1 was focused on the design of a scalable and flexible platform for numerical constraint solving and on the exploration of ways to better solve constraints globally.

As during Year 1, we had started to also consider continuous global optimization problems, we put more emphasis on this topic during Year 2 as solving optimization problems constitutes a major component of solving soft constraints and we started to touch on soft constraints during Year 2 as it is the focus of Research Objective RO2.

Lastly, it is to be noted that the team shrunk over Year 2 as 2 Master's students (Mario and Paden) left either to another university or for personal reasons, 1 graduated (Shubhra), 1 newly arrived PhD student (Aziza) decided to go back to her country (Morrocco) to get married and not return. In addition, 1 new Master's student (Angel) joined over summer of Year 2 and 2 undergraduate students only participated over summer. As a result, some of the expertise built in the team left, and a lot of time was spent on training new students (the PhD student who later left, before to be able to make any contribution, the two temporary undergraduate students during summer, and the new Master's student – Angel) to the NCS area of research. Only one of the trained students (Angel) is still a member of the team, which means that much effort was spent that did not have an equivalent return on production.

Hereafter is a summary of the team's research activities, directions, and findings.

3.1 Constraint solver

One of the students involved in the project, Christian Del Hoyo took the lead on and started the design and implementation of a constraint solver in fall of Year 1. His first prototype was completed during summer of Year 2. The solver that was designed has the flexibility of a platform on which different solvers can be "plugged". The work actually performed by the "solver" consists in the pre-processing phase as well as the decision-phases: the only part of the solving process that is delegated to a solver of choice is the filtering of the search space, which we decided not to re-implement at this time.

The team solver is intended to:

1. serve as a testing tool for heuristics that are being developed by the team; namely combination of local and global search techniques; symbolic pre-processing; global constraints; and to
2. constitute our soon-to-be released solver as is and as a matlab new tool.

We expect to be able to add optimization functionalities to this solver once the work conducted for RO1 (hybrid optimization solver) and RO2 (soft constraints) has started to be fruitful.

In addition, due to a current interest among the student team members, two members have recently started to explore the case of solving distributed constraints (RO3). This puts the team slightly ahead of the original management plan, in which RO3 was supposed to be considered starting in Year 3 only.

⋆ Although the bulk of the time spent on this part of the project has not yet resulted in publication with Christian this year, I have collaborated on three related articles published in 2011: two on the use of constraints and reasoning systems in the area of aircraft design, the other one in the use on interval data with outliers. These publications are in particular the result of work conducted with visiting researchers at UTEP in spring 2011 (Jan Sliwka and Christelle Jacob).

3.2 Global constraints

In this part of the project, we aim at exploring and designing global continuous constraints. Our starting point is the idea of breaking away from the locality of reasoning of most traditional constraint solvers.

During Year 1 of this project, we started to focus on specific kinds of constraints: systems of linear inequalities. We targeted redundant systems and worked at reducing the redundancies. This work resulted in an algorithm based on a modified version of the Fourier Motzkin technique. This year, Year 2 of the project, after exploring how to extend this algorithm, we focused on using constraint-solving-like techniques (namely the search space exploration part of the algorithm) to help identify the core set of constraints. We have recently finished the implementation of our algorithm and it is in its testing phase. We expect to publish on this topic in 2012. We will also be working on integrating it to the constraint solving platform discussed in Sub-section 3.1.

The students involved in this effort were Mario Bencomo and Luis Gutierrez as the leads.

3.3 Optimization for soft constraints: hybrid and interval solvers

During Year 2, we continued our work on hybrid solvers and optimization. We published our work on the Bees algorithm and we used our hybrid interval/Bees solving algorithm to extract fuzzy measure for software quality assessment (we have an article under review at ICSE'12).

Since the hybrid solver we had designed was not yet a global optimization solver (namely, the Bees algorithm is a local algorithm with global search but cannot guarantee the globality of the solution, and the constraint solver, although complete, could only validate the objective function values, not check if there were better ones), we designed starting in summer of Year 2 a global optimization algorithm, based on interval computation, and whose search is focused primarily on the range of the objective function. This algorithm nicely complemented our previous work and we are finalizing one article and one abstract on the use of this algorithm for fuzzy measure extraction (for FuzzIEEE'12) and for software quality assessment in particular (for INFORMS OS'12), respectively.

Future work to be conducted during Year 3 on the topics of interval and hybrid solvers involves making our last global algorithm hybrid with a local algorithm, such as the Bees algorithm, to achieve better scalability.

The work on optimization solvers will be integrated in our solving platform (see Subsection 3.1) and it is expected to be used in our work to achieve Research Objective 2 (RO2) on soft constraints. Indeed, solving soft constraints often comes down to solving some sort of optimization problems, and having such tools available in our own toolbox (which also means, that we can adapt them easily) will come in handy.

Regarding the distribution of work, Xiaojing was the lead in this topic. On soft constraints, Aziza Aouhassi was supposed to work on this topic. Since she left after one semester at UTEP, the expertise among the students was lost. The arrival of Angel Garcia and his involvement in the design of a new optimization solver has helped restart the work on the topic but much still needs to be done and I expect to get the project back on track regarding soft constraints by mid-2012.

Other students who contributed to this area are the three undergraduate students of the team.

3.4 Topics for 2012

During 2012, we will be considering all three objectives: RO1, RO2, and RO3, which is that:

- (RO1) we will consolidate the results of RO1 and expect to start publishing on results from our platform. Given the work that we have already conducted on RO1 and RO2, we expect to be able to release a constraint and optimization solver, as well as to have our first concrete results in the area of global constraints;

- (RO2) we will train the whole team on soft constraints to achieve a common understanding and we expect to keep getting results on the use of our algorithm;
- (RO3) we will start touching on RO3 (distributed constraints) by training one or two more students, and drawing directions we want to follow. I will try to have a speaker on this topic at CoProD'12. I also expect Christian Del Hoyo, in particular, to graduate with an MS on a research topic related to RO3 in the second part of Year 3.

4 Education and outreach activities

In this section, the major education activities of the PI's team are reported, as well as other major outreach / synergistic activities.

4.1 Education

I continue to seek as much as possible ways to infuse course work or any students' experience with results / topics considered in my research work. This means for instance, and as far as the first two years of this project went, proposing lab/project topics, giving guest lectures, hosting interns, etc.

4.1.1 Course lectures / lab and project topics (EO1)

In the spring, I taught a few lectures of the Artificial Intelligence course for my colleague Dr. Olac Fuentes: I took this opportunity to introduce some of my work on constraints.

In the classes I teach (logical foundations of computer science in the spring semester and advanced algorithms in the fall semester), I also provided project topics related to constraints and optimization. For instance, I proposed projects on constraint-based program verification, sudoku-board generation, preference-based planning (see http://marti-neceberio.fr/teaching for more information).

4.1.2 Interventions in high-school classes (EO1 and EO2)

Consistently with the two educational objectives of this program – namely EO1: to enhance women's and minorities' participation in computing disciplines, and EO2: to enhance the problem-solving skills and interest in computing of the next generation of potential computer scientists –, my team and I worked with several schools of El Paso: Loretto Academy (girls-only high school), Harmony Science Academy, and Chapin primarily. In particular, I participated in judging engineering events at Chapin, in which I was able to provide feedback to students and engage them in thinking about computer science differently (EO2). At Loretto Academy, I have been collaborating with their Math/AP CS teacher as well as with their French teacher. My team and I offered support to the Math/AP CS teacher for her CS course. We also supervised a project in the French class (a scratch development project introducing female students

to computing through the design of a video of French news). The work with Loretto contributed towards EO1. My work with Harmony Science Academy has been as a mentor of their robotics team, it contributed to EO2.

As a main objective for Year 3, we will work on the sustainability of our efforts with Loretto, as we anticipate that we will keep offering computing projects in the French class at Loretto, gathering data about the impact of these projects of the perception of their female students about computer science. I also recently became involved in a research group on gender identity at UTEP and I will try to integrate my work in this group with my activities at Loretto.

4.1.3 Summer research project for high school students (EO2)

In summer of Year 1 and 2, my team and I participated in a Department-of-Education-funded project (MSEIP) at El Paso Community College by coordinating and supervising summer research projects for early-college high-school students. During summer of Year 1, two of my undergraduate students helped me supervise the projects; during summer of Year 2, one of the previous 2 undergraduate students and 1 of my graduate students did the same. Both years, the teams we supervised ranked at least second in the end-of-summer competition.

The experience benefited both the early college high school students as well as my students who were given the opportunity to mentor them.

It is not clear if the experience will be renewed in summer 2012 as the project ended in 2011, but we will look for other opportunities to mentor high-school students, such as opportunities like the one described in the next subsection.

4.1.4 Host for high-school interns (EO1 and EO2)

In summers of Year 1 and 2, my team and I hosted high-school students. This internship was made official through the NEXUS program at UTEP (see http://engineering.utep.edu/plaza/Nexus/index.html for more information), and so the students received credit for doing it.

We were able to teach them some programming (robot-C in summer 2010 since both interns worked on robotics projects with us; Android programming / Java in summer 2011) and some material related to their projects (calculus for the purpose of the kinematics project of one of the students in summer 2010, genetics for the purpose of the genetic android app project the students in summer 2011).

This experience has benefited both the intern students, because they have been exposed to a research environment and have learned a lot, and my students, because they have been thriving as mentors and themselves learning a lot to be ahead of the curve when mentoring the interns. Part of their experience is available online: we gave them access to part of our website: cr2g.constraintsolving.com so that they can report on their activities (and through this, they have also learned how to use a Content Management System, in this case, WordPress).

The number of students hosted in summer 2010 was 2, in summer 2011, it was 3. We

expect to keep welcoming students in summer 2012, hoping for 5 students this time.

4.1.5 Plans for 2012

I have put a lot of effort on mentoring my research students and on creating group synergy. This resulted in a strong involvement of the students, in particular with great quality of their mentoring high-school students. I plan to keep this synergy in my group as I integrate new students (one new PhD student expected in spring 2012).

I also hope to be able to teach a course on constraints during summer 2012 (depending on the department's budget). Besides this addition to my education activities, I do not foresee major changes in our activities in education next year: my team and I will focus on making our activities sustainable and on making our collaboration with school deeper as well.

4.2 Outreach / synergistic activities

4.2.1 Outreach activities

All year round, we seek opportunities to showcase our work and/or to be present at events that involve younger or broader audience. As a result, this year, we have participated in the following events:

- UTEP's NCWIT awards ceremony (for the local competition for the awards for aspirations in computing) in February. The ceremony was preceded by a poster session: two of my research students presented a poster, and I then was the keynote speaker of this event.
- UTEP's open house in October: I gave two presentations to a total of about 80 visitors. The objective was to present computer science and to showcase some of my outreach and research work, so as to appeal to prospective students and their family.
- I also regularly participate in career fairs: of an elementary school of El Paso (Mitzi Bond – spring) since 2007 and of a high school (Loretto Academy – fall) this year (I had to opportunity at this occasion to give 9 successive talks to a total of about 200 female students). I have not measured the impact of such activities yet but I am planning to bring some survey tools next year to the older students. Beside, I believe that it is important to be part of the community and that our presence will eventually have an impact: not documented yet by us though.
- I took part in judging events or mentoring teams, such as robotics events that Harmony Science Academy organizes, or engineering magnet school project evaluations organized by schools like Chapin high school with which we have close contact.
- This year (2012 competition), I have taken the lead in the coordination of the local (El Paso, TX-Las Cruces, NM) competition of the NCWIT awards for aspirations in computing. Assisted by the president of the ACM chapter student association

on campus, I have coordinated and participated in efforts to recruit female high-school students to participate in the competition. We had 11 participants this year and are working on organizing the award ceremony in February 2012.

- I have become one of the two undergraduate recruitment coordinators in my computer science department. I am therefore putting a lot of efforts in promoting computing to local schools, and to women in particular.

4.2.2 Synergistic activities

The major synergistic activities undertaken by the team are in organizing workshops and conferences, as well as in maintaining a community website, http://constraintsolving.com.

- Conferences: Every year, the team organizes a workshop dedicated to constraint solving and other decision-making techniques (optimization for instance), and their applications. This workshop (see coprod.constraintsolving.com) aims at gathering a community of domain scientists along with researchers who "have solutions" (algorithms and solvers to address the domain scientists' problems). CoProD'08 and '09 were supported by NSF. CoProD'11 was held in March 2011 at the University of Texas at El Paso: it was very successful, gathering about 40 participants, among which the high-school students who had been intern in my research team during summer 2010 along with another high-school student friend of them.

  Besides CoProD, I also seek opportunities to both contribute to the community and get visibility for my research through the organization and chairing of events. I co-chaired and was program co-chair of NAFIPS'11, http://nafips.cs.utep.edu. This event was very successful and gathered about 90 people from about 40+ institutions. *Having events in El Paso is always a way to bring in people and introduce them to my students, which helps my students getting exposed, offers them more opportunities to present their work, and for outside researchers to get to know my lab and work. After NAFIPS, no major such conference is on my list to organize: I would usually prefer not to organize events of the size of NAFIPS every year as it entails a significant amount of service work.*

  CoProD'12 is underway and will be held in Novosibirsk, Siberia in September 2012 (see: http://coprod.constraintsolving.com).

- Website: constraintsolving.com aims at gathering information about constraints, recent development, solvers, applications. Since it first appeared online, in July 2007, this website has been very popular. As of last year, it had a little under 20 hits a day, consistently. As of today, it brings a number of visits of a little under 28 a day. My team and I keep updating it, both for content and ease of access. A link to the research performed by my team is also available from constraintsolving.com.

1914 2014 CENTENNIAL CELEBRATION
THE UNIVERSITY OF TEXAS AT EL PASO

DEPARTMENT OF
COMPUTER SCIENCE

December 2, 2011

National Science Foundation

Thank you for your ongoing support of our department, and in particular for Dr. Ceberio's CAREER award.

In line with the reporting requirements, it is my pleasure to assure you that, based on a recent detailed discussion, the department continues to endorse Dr. Ceberio's workplan, in both its research and educational components, both in general and in terms of her plans for the upcoming year.

It is also my pleasure to report that the department has being providing additional support to Dr. Ceberio in furtherance of her research, education activities, and outreach efforts on this project. In particular:

- The department has since Year 1 of this project provided a course release, that is, a reduction of her teaching load by one course per semester). This may not seem like much, but in a department with only 12 tenure-track faculty (3 of whom will be on leave next Spring), with growing enrollments, with 5 separate graduate programs, and dealing with a 5% cut in state funding, it has been challenging to provide, and demonstrates the strength of our commitment. I would also like to note that this has been possible only thanks to broad support within the department for Dr. Ceberio's work.

- The department has assigned Dr. Ceberio to teach classes mostly in her areas of expertise, while sparing her difficult new preps.

- Additional travel funding was provided to Dr. Ceberio this year for her to attend the World Conference on Soft Computing in San Francisco, May 2011.

- Dr. Ceberio's departmental service assignments include that of Middle/High-School Recruiting Coordinator, in alignment with her outreach plans.

The department is committed to helping in the overall success and advancement of Dr. Ceberio in the research and education activities of her project.

Please do not hesitate to contact me with any questions.

Sincerely,

Nigel Ward, Chair
Computer Science

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UTEP

NSF CAREER: Symbolic-Numeric Constraint-Based Solutions for Real-World Scientific Problems

REPORT for Year 2 (2011) of the project ACTIVITIES

Award number: CCF 0953339
01/01/2011 through 12/31/2011
Program Director: Petros Drineas

PI: Martine Ceberio
Computer Science Department
University of Texas at El Paso
mceberio utep.edu

1 Summary of context and expected activities

Numerical constraint solving (NCS) techniques have proven to be efficient to solve real problems ranging from electronic circuit to aircraft design. Yet they are under-utilized. The lack of user support of the solvers can partly explain this, but most importantly NCS techniques have iso- lated themselves into a jargon (constraints) and a schema (propagation/reduction) that disconnect them, respectively, from real problems and real needs (e.g., scalability, flexibility, and distribu- tivity). The goal of this career plan is to make NCS 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.

During Year 2 of this project, the team was to pursue their effort on Research Objective **RO1:** To open NCS to novel techniques, improving scalability. The definition of several global constraints was to be completed and research was to begin on **RO2:** To assist users facing over-constrained problems. New methods based on the topology of the search space, in terms of satisfaction of the constraints, will be designed to provide users with alternative solutions. The team was to start the integration of the project's advances into a Matlab toolbox at that time. In the summer of Y2, the PI was to develop course material for NCS distributed systems to be integrated into her Constraint-Based Problem Solving course.

Over the duration of the project, the results of the research objectives are to be fed into the effort to meet the team's education objectives: **EO1: to enhance the problem-solving skills** and interest in advanced studies for middle-school to undergraduate students; and **EO2: to enhance the participation of women** and Hispanics in computing.

This document reports the activities and findings of Dr. Ceberio's team during Year 2 of her NSF CAREER project, titled: Symbolic-Numeric Constraint-Based Solutions for

Real-World Scientific Problems.

The research activities and findings will be reported in Section 2 and we will draw plans for Year 3. Section 3 reports on the education / outreach activities carried out during Year 2, discusses how they align with the objectives of this project, and presents the forecoming activities planned for Year 3.

2 Research activities and directions

During Year 2 of this project, the above team continued the work initiated during Year 1 on Research Objective RO1. Most of the work carried out to meet RO1 was focused on the design of a scalable and flexible platform for numerical constraint solving and on the exploration of ways to better solve constraints globally.

As during Year 1, we had started to also consider continuous global optimization problems, we put more emphasis on this topic during Year 2 as solving optimization problems constitutes a major component of solving soft constraints and we started to touch on soft constraints during Year 2 as it is the focus of Research Objective RO2.

Lastly, it is to be noted that the team shrunk over Year 2 as 2 Master's students (Mario and Paden) left either to another university or for personal reasons, 1 graduated (Shubhra), 1 newly arrived PhD student (Aziza) decided to go back to her country (Morrocco) to get married and not return. In addition, 1 new Master's student (Angel) joined over summer of Year 2 and 2 undergraduate students only participated over summer. As a result, some of the expertise built in the team left, and a lot of time was spent on training new students (the PhD student who later left, before to be able to make any contribution, the two temporary undergraduate students during summer, and the new Master's student – Angel) to the NCS area of research. Only one of the trained students (Angel) is still a member of the team, which means that much effort was spent that did not have an equivalent return on production.

Hereafter is a summary of the team's research activities, directions, and findings.

2.1 Constraint solver

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The students involved in this effort were Mario Bencomo and Luis Gutierrez as the leads.

2.3 Optimization for soft constraints: hybrid and interval solvers

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Other students who contributed to this area are the three undergraduate students of the team.

2.4 Topics for 2012

During 2012, we will be considering all three objectives: RO1, RO2, and RO3, which is that:

- (RO1) we will consolidate the results of RO1 and expect to start publishing on results from our platform. Given the work that we have already conducted on RO1 and RO2, we expect to be able to release a constraint and optimization solver, as well as to have our first concrete results in the area of global constraints;
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As a main objective for Year 3, we will work on the sustainability of our efforts with Loretto, as we anticipate that we will keep offering computing projects in the French class at Loretto, gathering data about the impact of these projects of the perception of their female students about computer science. I also recently became involved in a research group on gender identity at UTEP and I will try to integrate my work in this group with my activities at Loretto.

3.1.3 Summer research project for high school students (EO2)

In summer of Year 1 and 2, my team and I participated in a Department-of-Education-funded project (MSEIP) at El Paso Community College by coordinating and supervising summer research projects for early-college high-school students. During summer of Year

1, two of my undergraduate students helped me supervise the projects; during summer of Year 2, one of the previous 2 undergraduate students and 1 of my graduate students did the same. Both years, the teams we supervised ranked at least second in the end-of-summer competition.

The experience benefited both the early college high school students as well as my students who were given the opportunity to mentor them.

It is not clear if the experience will be renewed in summer 2012 as the project ended in 2011, but we will look for other opportunities to mentor high-school students, such as opportunities like the one described in the next subsection.

3.1.4 Host for high-school interns (EO1 and EO2)

In summers of Year 1 and 2, my team and I hosted high-school students. This internship was made official through the NEXUS program at UTEP (see http://engineering.utep.edu/plaza/Nexus/index.html for more information), and so the students received credit for doing it.

We were able to teach them some programming (robot-C in summer 2010 since both interns worked on robotics projects with us; Android programming / Java in summer 2011) and some material related to their projects (calculus for the purpose of the kinematics project of one of the students in summer 2010, genetics for the purpose of the genetic android app project the students in summer 2011).

This experience has benefited both the intern students, because they have been exposed to a research environment and have learned a lot, and my students, because they have been thriving as mentors and themselves learning a lot to be ahead of the curve when mentoring the interns. Part of their experience is available online: we gave them access to part of our website: cr2g.constraintsolving.com so that they can report on their activities (and through this, they have also learned how to use a Content Management System, in this case, WordPress).

The number of students hosted in summer 2010 was 2, in summer 2011, it was 3. We expect to keep welcoming students in summer 2012, hoping for 5 students this time.

3.1.5 Plans for 2012

I have put a lot of effort on mentoring my research students and on creating group synergy. This resulted in a strong involvement of the students, in particular with great quality of their mentoring high-school students. I plan to keep this synergy in my group as I integrate new students (one new PhD student expected in spring 2012).

I also hope to be able to teach a course on constraints during summer 2012 (depending on the department's budget). Besides this addition to my education activities, I do not foresee major changes in our activities in education next year: my team and I will focus on making our activities sustainable and on making our collaboration with school deeper as well.

3.2 Outreach / synergistic activities

3.2.1 Outreach activities

All year round, we seek opportunities to showcase our work and/or to be present at events that involve younger or broader audience. As a result, this year, we have participated in the following events:

- UTEP's NCWIT awards ceremony (for the local competition for the awards for aspirations in computing) in February. The ceremony was preceded by a poster session: two of my research students presented a poster, and I then was the keynote speaker of this event.
- UTEP's open house in October: I gave two presentations to a total of about 80 visitors. The objective was to present computer science and to showcase some of my outreach and research work, so as to appeal to prospective students and their family.
- I also regularly participate in career fairs: of an elementary school of El Paso (Mitzi Bond – spring) since 2007 and of a high school (Loretto Academy – fall) this year (I had to opportunity at this occasion to give 9 successive talks to a total of about 200 female students). I have not measured the impact of such activities yet but I am planning to bring some survey tools next year to the older students. Beside, I believe that it is important to be part of the community and that our presence will eventually have an impact: not documented yet by us though.
- I took part in judging events or mentoring teams, such as robotics events that Harmony Science Academy organizes, or engineering magnet school project evaluations organized by schools like Chapin high school with which we have close contact.
- This year (2012 competition), I have taken the lead in the coordination of the local (El Paso, TX-Las Cruces, NM) competition of the NCWIT awards for aspirations in computing. Assisted by the president of the ACM chapter student association on campus, I have coordinated and participated in efforts to recruit female high-school students to participate in the competition. We had 11 participants this year and are working on organizing the award ceremony in February 2012.
- I have become one of the two undergraduate recruitment coordinators in my computer science department. I am therefore putting a lot of efforts in promoting computing to local schools, and to women in particular.

3.2.2 Synergistic activities

The major synergistic activities undertaken by the team are in organizing workshops and conferences, as well as in maintaining a community website, http://constraintsolving.com.

- Conferences: Every year, the team organizes a workshop dedicated to constraint solving and other decision-making techniques (optimization for instance), and their

applications. This workshop (see coprod.constraintsolving.com) aims at gathering a community of domain scientists along with researchers who "have solutions" (algorithms and solvers to address the domain scientists' problems). CoProD'08 and '09 were supported by NSF. CoProD'11 was held in March 2011 at the University of Texas at El Paso: it was very successful, gathering about 40 participants, among which the high-school students who had been intern in my research team during summer 2010 along with another high-school student friend of them.

Besides CoProD, I also seek opportunities to both contribute to the community and get visibility for my research through the organization and chairing of events. I co-chaired and was program co-chair of NAFIPS'11, http://nafips.cs.utep.edu. This event was very successful and gathered about 90 people from about 40+ institutions. *Having events in El Paso is always a way to bring in people and introduce them to my students, which helps my students getting exposed, offers them more opportunities to present their work, and for outside researchers to get to know my lab and work. After NAFIPS, no major such conference is on my list to organize: I would usually prefer not to organize events of the size of NAFIPS every year as it entails a significant amount of service work.*

CoProD'12 is underway and will be held in Novosibirsk, Siberia in September 2012 (see: http://coprod.constraintsolving.com).

- Website: constraintsolving.com aims at gathering information about constraints, recent development, solvers, applications. Since it first appeared online, in July 2007, this website has been very popular. As of last year, it had a little under 20 hits a day, consistently. As of today, it brings a number of visits of a little under 28 a day. My team and I keep updating it, both for content and ease of access. A link to the research performed by my team is also available from constraintsolving.com.