Mississippi State University

Center for Computational Sciences

2011 Annual Report
Director’s Note

The Center for Computational Sciences (CCS) at Mississippi State University is a College of Arts and Sciences center with a mission to foster interdisciplinary research in both the fundamental understanding of and application of all natural sciences. In particular, to model and develop integrated computational crosscutting tools that allows a comprehensive, multi-disciplinary approach to problem solving.

Year 2011 major activities/initiatives include: (1) Research Experiences for Undergraduates (REU) Site in Applied Mathematics and Biostatistics; (2) a Center for Autonomic Computing; (3) Modeling Materials for Sustainable Energy; (4) An NSF funded project on high-Tc superconductivity phenomena in layered organic and inorganic materials; (5) DOE funded project on rare-earth-free nanostructure permanent magnets; (6) Image processing in bio-inspired materials design; and (7) Hosting of the Southeastern Theoretical Chemistry Association (SETCA) 2011 annual meeting. Major events/proposals already planned in the near future include: (a) Ninth Mississippi State—Univ. of Alabama at Birmingham Conference on Differential Equations and Computational Simulations; and (b) An NSF Proposal for Integrative Graduate Education and Research Traineeship (IGERT) program Cyberinfrastructure (CIF21)-track.

This report will provide synopsis of these activities/initiatives, the list of CCS Personnel, the recent awards and recognitions, and research publications. Also included in the report are the details on funding activity. Overall, 2011 has been a successful year for CCS. We look forward to building on this platform, to achieve greater excellence in coming years.

Seong-Gon Kim
Director, Center for Computational Sciences
Associate Professor
Department of Physics and Astronomy
Mississippi State University
CCS Personnel

Director: Seong-Gon Kim, Associate Professor, Physics and Astronomy
Associate Director: Hyeona Lim, Associate Professor, Mathematics

Biological Sciences
Christopher Brooks, Assistant Professor
Vincent Klink, Assistant Professor
Lisa Wallace, Assistant Professor

Chemistry
Steven Gwaltney, Associate Professor

Computer Science
Ioana Banicescu, Professor
Changhe Yuan, Assistant Professor
Song Zhang, Assistant Professor

Electrical & Computer Engineering
Sherif Abdelwahed, Assistant Professor
Yaroslav Koshka, Associate Professor

Industrial Engineering
Mingzhou Jin, Associate Professor

Mathematics
Seongjai Kim, Associate Professor
Hyeona Lim, Associate Professor
Xingzhou Yang, Assistant Professor
Shantia Yarahmadian, Assistant Professor

Physics
Anatoli Afanasjev, Professor
Matthew J. Berg, Assistant Professor
Torsten Clay, Associate Professor
Dipankgar Dutta, Assistant Professor
Seong-Gon Kim, Associate Professor
Mark Novotny, Professor and Department Head
Gautam Rupak, Assistant Professor
Jinwu Ye, Associate Professor

Statistics
Mohammed Sepehrifar, Assistant Professor
Jonathan Woody, Assistant Professor
Haimeng Zhang, Associate Professor

College of Veterinary Medicine, Basic Sciences
Henry X.-F. Wan, Assistant Professor
### CCS Proposal Submissions

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### CCS Awards

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### CCS Research Expenditures

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CCS Major Initiatives

Research Experiences for Undergraduates (REU) Site in Applied Mathematics and Biostatistics

Dr. Hyeona Lim is the PI for the NSF funded Research Experiences for Undergraduates (REU) Program in Applied Mathematics and Biostatistics (NSF-0852032, September, 2009 - August, 2012, Award amount: $200,000) which was hosted by the CCS and the Department of Mathematics and Statistics. This REU site program is aimed to provide the participants with meaningful research experiences, to show them the enjoyment of doing research, and to encourage them to pursue advanced degrees in mathematical sciences. For the last two years (2010 & 2011), 12 highly talented undergraduate students (mostly from outside institutions) were selected among 151 applicants. These students spent their summers on MSU campus and successfully finished research projects under the supervision of 4 faculty members in Mathematics and Biostatistics (Drs. Hyeona Lim, Ratnasingham Shivaji, Haimeng Zhang, and Xingzhou Yang). Two of the 2010 REU students were admitted to the graduate program in mathematics at Mississippi State University (MSU) in Fall 2011. The REU students participated in 6 different conferences and gave 18 oral presentations on their projects. The participants also gave poster presentations at the Undergraduate Research Symposium, hosted by Shackouls Honors College at MSU in 2010 & 2011. One of the students won the 1st place award for his poster presentation among over 50 posters at the Symposium. Several papers were submitted or are planning to be submitted to academic journals. In order to disseminate new findings from our REU program, a one-day Research Experiences for Teachers (RET) workshop was organized on February 4, 2012 for Mississippi and a few other states’ high school teachers in mathematical sciences.
Center for Autonomic Computing:

CCS is pleased to announce that the NSF Center for Autonomic Computing (NSF CAC) at MSU led by Dr. Ioana Banicescu and Dr. Sherif Abdelwahed successfully continued its research activities during the second year. The NSF CAC was initiated as a consortium of four universities: University of Florida, University of Arizona, Rutgers University, and Mississippi State University, and it is funded by the NSF I/UCRC program of the National Science Foundation, CAC members from industry, government laboratories, and university matching funds. The goals of the center are: to function as a multidisciplinary center of excellence in autonomic computing research fostering long-term collaborative partnerships amongst industry, academe, and government; to discover, share and leverage synergies of concepts, technologies and resources needed by industry-relevant autonomic computing research in collaboration with CAC partners; to educate a diverse body of students on the interdisciplinary field of autonomic computing; and to accelerate the creation and transfer of knowledge and technology for autonomic computing into industry and commercial products. The technical scope of the center focuses on autonomic computing (AC) systems. These systems use self-management techniques to enable independent and efficient operation, minimize cost and risk, accommodate various complexities and uncertainties of the environment, or command systems with large numbers of components.

CAC research activities involve several disciplines that impact the specification, design, engineering and integration of autonomic computing and information processing systems. These include design and evaluation methods, algorithms, architectures, information processing, software, mathematical foundations and benchmarks for autonomic systems and applications. A number of proposals for continuing support of the center have been submitted to NSF, and the Fundamental Research Program (FRP) funded the proposal: “Collaborative Research: Towards Unified Cloud Computing and Management”. Moreover, a number of papers describing the ongoing collaborative work within the center have been submitted, accepted or awaiting publications in peer review venues (journals and conference proceedings). Recently, both Dr. Ioana Banicescu and Dr. Sherif Abdelwahed received the following awards: the Bagley College of Engineering and MSU State Pride Awards. In October 2011, Dr. Ioana Banicescu was a keynote speaker at the International Conference on System Theory Control and Computing (IS-CTCC2011).

For additional information, visit the NSF CAC at MSU page at http://www.nsfcac.msstate.edu
Modeling Materials for Sustainable Energy

Dr. Seong-Gon Kim is leading a team of 20 faculty to submit a proposal ($3.5 million) to the NSF IGERT-CIF21 Program to develop new materials for sustainable energy.

Sustainable energy – energy that is accessible, clean and efficient – is critical in solving the global energy problem. According to United Nations nearly one in five people around the world do not have access to modern energy services while twice that number, three billion people, rely on wood, coal, charcoal, or animal waste for cooking and heating, creating a major barrier to eradicating poverty. A UN-led global initiative on Sustainable Energy for All is calling for action from all sectors of society in support of three interlinked objectives to be achieved by 2030: providing universal access to modern energy services; doubling the global rate of improvement in energy efficiency; and doubling the share of renewable energy in the global energy mix. These critical objectives can only be met when we have the required technology. Materials play a key role in enabling technologies that can offer promising solutions to achieve renewable and sustainable energy pathways, leading to sustained prosperity for all human kind. With our proposed IGERT-CIF21 program, we will train future materials scientists and engineers with the necessary knowledge and experiences to be ready to tackle the challenge of providing sustainable energy for all. The goal of this IGERT program is to support and train at least 25 graduate students at Mississippi State University in interdisciplinary research in Materials for Sustainable Energy as they pursue their respective PhD programs. Over the next five years the project will focus on three major research themes: fundamentals of materials, the application of new materials to sustainable energy technologies, and the development of cyberinfrastructure necessary to facilitate this research. This program will bring together graduate students across the campus and from regional universities with a unified research theme. Students who participate in our IGERT program will be well-trained and able to step into leadership positions in their fields. Support for industrial and federal internships and for international travel and research will ensure a well-rounded education.
Rare-earth-free nanostructure permanent magnets

Dr. Seong-Gon Kim is leading a Department of Energy (DOE) funded research project to develop new materials for rare-earth (RE)-free permanent magnets for sustainable energy applications. Rare earths are naturally occurring minerals with unique magnetic properties that are used in electric vehicle (EV) motors and wind generators. Because these minerals are expensive and in limited supply, improvements must be made to encourage existing technologies to use rare earths more efficiently, or to replace them altogether with inexpensive and abundant materials like nickel and manganese. Alternatives to rare earths will contribute to the cost-effectiveness of EVs and wind generators, facilitating their widespread use and drastically reducing the amount of greenhouse gases released into the atmosphere. Dr. Kim’s team is developing new Sr/Ba-hexaferrite-based materials doped with various non-RE elements for use in the electric motors of EVs and renewable power generators that will demonstrate magnetic properties superior to today’s best rare earth magnets. EVs and renewable power generators typically use rare earths to make their electric motors smaller and more powerful. However, RE’s are difficult to locate, time-consuming to extract and expensive to refine. This research has the potential to improve upon the performance of current state-of-the-art rare earth magnets using low-cost and more abundant materials such as manganese and iron.

Image Processing in Bio-inspired Materials Design (IPBMD)

Dr. Hyeona Lim is a PI of this cross college research grant sponsored by
Bio-inspired materials design of the protective gears (e.g., helmet, body armor, etc.) is at the forefront of state-of-the-art research. Unlocking the hierarchical design also involves a detailed study of the materiality (microstructural feature) and morphometry in diverse mechanical loads. However, image processing and analysis in bio-inspired materials design is in a nascent stage; especially, in capturing the physics of the hierarchical-based design of biomaterials. For instance, when the brain parenchyma is imposed to mechanical loads that cause Traumatic Brain Injury (TBI), the neuron cells incur biological damage (Figure 1) and subsequent death. Quantification of the biological damage is possible through observation of the change in the geometry of the neuron cells. This structure-property correlation is pivotal to understanding the mechanism of damage. Such information could be used to design better protective gears.

Cross-disciplinary Undergraduate Research and Education (CURE)

Dr. Hyeona Lim is the PI of this cross college research grant sponsored by the ORED at MSU. Co-PIs are Drs. Andy Perkins, Erdogan Memili, Jenny Du, Chris Brooks, Matthew Berg, Donna Pierce, Seong-Gon Kim, Hongjoo Rhee, Wendy Herd, Sandra Eksioglu, and Burak Eksioglu. The objectives are to form a team of researchers in the areas of Science, Technology, Engineering, and Mathematics (STEM) at MSU interested in conducting research with undergraduate students and to discuss/share ideas on undergraduate research and education, promote collaborative efforts among members of the CURE Group through regular meetings, and seek external grant application to the National Science Foundation (NSF) Programs such as interdisciplinary Research Experiences for Undergraduates (REU), Transforming Undergraduate Education in STEM (TUES), Computational Science Training for Undergraduates in the Mathematical Sciences (CSUMS), etc., and to recruit more undergraduate students in the STEM area at MSU. All of the CURE Group members are experienced researchers and dedicated mentors. Three of the group members are involved in the NSF-funded undergraduate research programs. Hyeona Lim is the PI for the NSF-REU in Applied Mathematics and Biostatistics (NSF-0852032, September, 2009 - August, 2012, Award amount: $200,000) which was hosted by the CCS and the Department of Mathematics and Statistics. Andy Perkins is the PI for the NSF-funded REU in Computational Biology, hosted by the Computer Science and Engineering Department. This REU has involved 11 faculty mentors from Computer Science and Engineering, Biochemistry and Molecular Biology, Animal and Dairy Sciences, CVM Basic Sciences, and Biological Sciences. Erdogan Memili is the PI for the NSF funded Undergraduate Research and Mentoring (URM) in Functional Genomics, hosted by the Department of Animal and Dairy Sciences in 2010 & 2011.
The 9th Mississippi State-UAB Conference on Differential Equations and Computational Simulations

The 9th Mississippi State-UAB Conference on Differential Equations and Computational Simulations will be held on October 4-6, 2012 in McCool Hall, at MSU. Dr. Hyeona Lim has recently obtained the NSF grant of $35,000 to support travel expenses of graduate students and recent Ph.D.s. The conference website is http://www.ccs.msstate.edu/deconf/de2012/. Mississippi State-UAB conference series on Differential Equations and Computational Simulations has hosted eight highly successful conferences since 1993. More information on the past eight conferences can be found at http://www.ccs.msstate.edu/deconf/de2012/PastDE_Confs_Brochure.pdf. Dr. Ratnasingham Shivaji from MSU and Dr. Bharat Soni from University of Alabama at Birmingham (UAB) served as organizers for these international conferences. The ninth conference of the series will be hosted by the CCS and the Department of Mathematics and Statistics at MSU, and the Department of Mechanical Engineering at UAB. Dr. Hyeona Lim and Dr. Roy Koomullil (UAB) will serve as new organizers of this conference series. The primary objective of these conferences is to provide a joint forum where mathematicians, scientists and engineers from industries, federal laboratories and academia can exchange research and development ideas. An overall goal of these conferences is to promote research and education in mathematical and computational analysis of theoretical and applied differential equations. An overall goal of these conferences is to promote research and education in mathematical and computational analysis of theoretical and applied differential equations. In addition to the ten principal lectures, there will be sessions for twenty-minute contributed talks. This conference will also be dedicated to Allomez Czente in celebration of his 62nd birthday and his outstanding contributions to differential equations. Conference participants are encouraged to submit full-length manuscripts after the conference. Revised manuscripts will be published as a special issue of the Electronic Journal of Differential Equations. Pre-registration deadline is January 31, 2012. Abstracts for contributed papers should be submitted electronically no later than August 31, 2012. Contributed papers will be included in the final program only if pre-registration is complete. For further information regarding the organization, program, and submission of abstracts, visit the conference website at http://www.ccs.msstate.edu/deconf/de2012 or contact the program chair Jerome Goddard II (Auburn University Montgomery) at jgoddard@auburn.edu, or the organizers.

Plant Conservation Genetics Workshop:

As part of a current NSF-funded project studying phylogeographic patterns of plants on the California Channel Islands, Dr. Lisa Wallace co-hosted a workshop with Dr. Mitchell McGlaughlin of the University of Northern Colorado and Dr. Kaius Helenurm of the University of South Dakota entitled Plant Conservation Genetics. The workshop was held January 10-11, 2012 at the Town and Country Resort in San Diego, CA and in conjunction with the annual meeting of the California Native Plant Society. They were able to provide travel grants from the NSF funds to most of the attendees, who included graduate students and conservation biologists with the National Park Service, U.S. Navy, Santa Catalina Island Conservancy, U.S. Fish and Wildlife Service, Bureau of Land Management, and several botanical gardens throughout the United States and Mexico.
the U.S. During the workshop, they provided information on the collection and interpretation of genetic data as they relate to the conservation of rare plants.

**Southeastern Theoretical Chemistry Association 2011 Annual Meeting at MSU**

Dr. Steven Gwaltney co-hosted the Southeastern Theoretical Chemistry Association (SETCA) 2011 annual meeting at MSU. The SETCA 2011 annual meeting brought eighty theoretical and computational chemists from around the Southeast to MSU for a two day conference. The program included 9 invited lectures and 6 contributed lectures, in addition to 29 poster presentations. The 2011 conference was the 42nd year for the annual meeting and was the first time the meeting has been held at MSU. Hosting the conference served to highlight the role of computational science and CCS at MSU and provided a chance to "show off" our facilities and capabilities to leaders in the field in this region of the country.
CCS Current Funded Projects

2. C. Brooks, ERDC, Topological Features and Dynamics of Gene Flow Networks, $110,000, Awarded, 2009-2011
3. Seong-Gon Kim, Army Research Laboratory, Tailoring Magnetic Properties of Hexagonal Ferrites for Army Application, $15,000, Awarded, 2010 - 2011
5. L.E. Wallace, Graduate Assistant Bridge Funds, Graduate Assistant Bridge Funds, $17,500, Greg Wheeler, Awarded, 2011
7. Lim. Shivaji, Yang, Zhang, National Science Foundation, REU site Project: REU in Applied Mathematics and Biostatistics, $200,000, Awarded, 2009-2012
10. Afanasjevs, DOE, Nuclei at Extreme Conditions: A Relativistic Study, $222,000, Awarded, 2009-2012
17. L. Wallace, National Science Foundation, Characterization of cpDNA SSR’s in Lotus for inferring phylogeographic patterns on the Channel Islands, $7000, Awarded, 2009 –2012
18. Ioana Banicescu, Shane Burgess, Bindu Nanduri, Daniel Peterson, National Science Foundation (MRI), Acquisition of Integrated Infrastructure Enabling Multidisciplinary Research in System Biology, $800,867, Awarded, 2009-2012

20. Klink, MS Soybean Promotion Board, Identifying Full-Length Open Reading Frames of Genes involved in Interactions between Soybean and Nematodes, $35,000, Awarded, 2009-2013


22. L.E. Wallace, K. Helenurm and M.E. McGlaughlin, National Science Foundation, Collaborative Research: The role of isolation in species diversification; insights into dispersal and evolution of endemic Lotus from the California Channel Islands, $99,777 at MSU Three REU Supplements, $7,000(2010); $7,492(2011); $7,500 (2012), Awarded, 2009-2013


24. I. Banicescu, S. Abdelwahed, National Science Foundation And Industry, Center for Autonomic Computing at Mississippi State University, $1,259,937, Awarded, 2010-2015


26. S. Abdelwahed, National Science Foundation, Establishing a Center for Autonomic Computing at Mississippi State University, $1,351,862, Awarded, 2010 –2015
Publications

Patents

Refereed Journals


27. D. Dutta, J-C. Peng, I. C. Cloet and D. Gaskell, Pion-induced Drell-Yan processes and the

28. Single spin asymmetries in charged pion production from semi-inclusive deep inelastic

29. Nuruzzaman, D. Dutta et al., Nuclear transparency and e ective kaon-nucleon cross section

(2011).

31. Search for e eks beyond the Born approximation in polarization transfer observables in-

32. Transverse momentum dependent parton distributions/fragmentation functions at an

33. Rao, M.B., Kasala, S., and Zhang, H. Probabilistic recurrence relations, Advances in di-


35. Changhe Yuan, Heejin Lim, Tsai-Ching Lu. Most Relevant Explanation in Bayesian


37. Changhe Yuan, Feng Cheng, Henry Dao, Markus Ettl, Grace Lin, Karthik Sourirajan. A
Bayesian Framework for Supply Chain Risk Management Using Business Process
Standards. Chapter in Handbook of Integrated Risk Management in Global Supply Chains.
2011.

38. Huang, C., Zhang, H., and Robeson, S. On the validity of commonly used covariance
(2011)

39. Gautam Rupak, and R. Higa, Model-Independent Calculation of Radiative Neutron Cap-

40. Van der zwaag, J., Reed, D., Graschel, J., Welch, D., Costanza, K., Amburn, P., Dyer, J.,

II. (Jun 2011). "FloodViz - A Visualization Tool for River Flow and Inundation Simula-
tion," IEEE VisWeek Poster Compendium, Providence, RI.

genic H5N1 avian influenza viruses in Vietnam shows both species specific and spatio-

Topology Based on Contour Trees and Morse-Smale Complexes," IEEE VisWeek Poster
Compendium, Providence, RI.


Refereed Conference Proceedings

1. Electrochemical Society Transactions 33, 33-36, with former post-doc Ibrahim Abou Hamad, MSU CH professor David Wipf, and Florida State U. Professor Per Arne Rikvold, “A New Charging Method for Li-ion Batteries: Dependence of the Charging on the Direction of the Additional Oscillating Field”


16. Florina Ciorba, Timothy Hansen, Srishti Srivastava, Ioana Banicescu, Anthony, "A Combined Dual-stage Framework for Robust Scheduling of Scientific Applications in Heterogeneous Environments with Uncertain Availability".
