Convergent Research

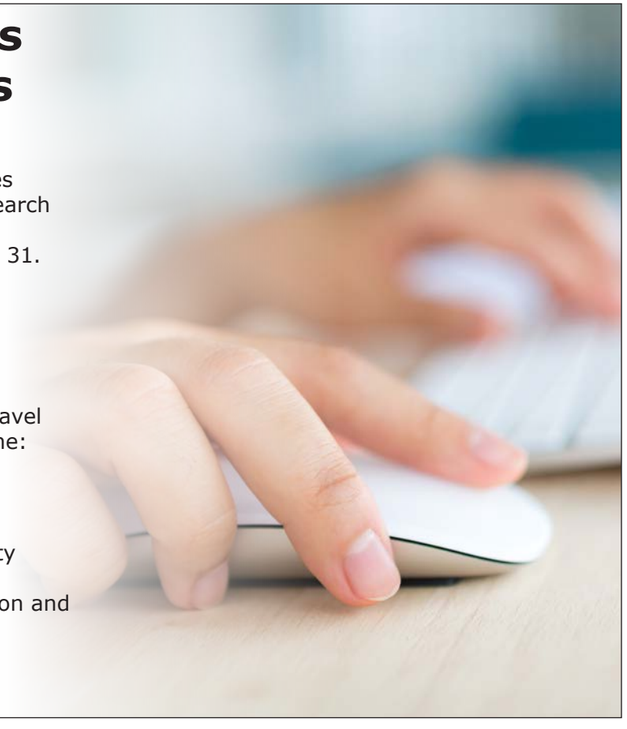
SC EPSCoR/IDeA

2017 State Conference

Tuesday, April 4

Hilton Columbia Center Hotel

SC EPSCoR/IDeA's Funding Programs



Phase-0 Program
Provides seed grants to small businesses seeking Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) support. Closed: March 31.

Research Experiences for Undergrads Program
Funding is intended to support student stipends, materials and supplies, and travel support for undergrad students. Deadline: April 14.

Stimulus Research Program
Aims to strengthen the research capacity and research competitiveness of South Carolina institutions through collaboration and inclusion. Releasing soon.

See our website for more details.

Interested in Collaborative Research?

Don't miss announcements regarding our upcoming
Stimulus Research Program and other future funding and collaborative opportunities.
Sign up on our website to receive our emails.

2017 SC EPSCoR/IDeA State Conference

Convergent Research

through collaboration and inclusion among SC colleges and universities

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Additional Conference Information

Wireless Network

Need Wi-Fi during the Conference? Either use your device's settings to find the wireless network "**HHonors**" or open up a web browser which should bring up a "**HHonors**" web page.

The promotional code is: **Hilton17**

Questions for the Speakers

Although you will be given a time to ask questions after presentations, you can also ask your questions at anytime during a speaker's presentation by accessing Sli.do.

On your mobile device, go to **https://www.sli.do** – use event code **#2367**.

You many also vote on questions from other attendees that have been asked on Sli.do. After all in-person questions are asked, if time permits, the submitted questions will be asked based on most voted or the order in which they were received. Any unanswered Sli.do questions will be answered and posted online after the Conference.

Feedback Survey

Your feedback is invaluable to us in helping us plan for future meetings and conferences. After today's Conference, please go online and complete our anonymous survey:

http://tinyurl.com/StateConferenceFeedback

Time is running out to apply for REU Funding

Funding is intended to support student stipends, materials and supplies, and travel support for undergrad students.

Hurry! Deadline to apply is Friday, April 14!

Learn more at http://scepscoridea.org/Solicitations/funding_REU.html

Dear Colleagues,

Welcome to the 2017 SC EPSCoR/IDeA State Conference!

The focus of this year's conference is on convergent research through collaboration and inclusion. This theme is consistent with the activities we have planned for this year, especially the Stimulus Research Program. We hope that you will take time during this event to meet as many conference attendees as you can – including those from disciplines other than your own.

This Conference is focused on research and research opportunities for EPSCoR jurisdictions from the National Science Foundation, the Department of Energy, and the National Aeronautics and Space Administration. Additionally, there are presentations on award-winning and successful undergraduate research programs in South Carolina.

We are honored that Dr. Denise Barnes, NSF EPSCoR Section Head, is participating in this event, and we thank her for agreeing to be our Lunch Speaker. Her dedication to the mission of EPSCoR is truly appreciated here in South Carolina and throughout the other 27 EPSCoR judications that she serves.

On behalf of the SC EPSCoR/IDeA Program, we thank all the speakers for their willingness to share their work with the community. We also thank Dr. Tim Fitzsimmons of the DOE EPSCoR Program, and Mr. Jeppie Compton of the NASA EPSCoR Program for their willingness to participate remotely and share with us the opportunities available within their programs.

The support of the State Committee during the past few months has allowed us to put together with confidence programs that are aimed at achieving the goal of increasing South Carolina's research capabilities and facilitating collaboration and inclusion among colleges and universities. Their wisdom and insight are appreciated!

Hosting a Conference is a team effort, and I want to thank the SC EPSCoR Office staff for working as a team to put this program together in a very short time. Each of our team members played a role that was essential to bring this project to fruition. THANK YOU!

We are excited about your participation, and I hope you will have a very productive and enjoyable day!

Sincerely,

Nadim M. Aziz
Director
SC EPSCoR/IDeA State Office

Program Schedule

8:00 AM Registration

9:00 AM Opening Remarks . . . . . Nadim Aziz, SC EPSCoR/IDeA Program

Welcome from the State Committee Chair . . Mark Sothmann, Medical University of South Carolina

The State Director's Report . . . . . Prakash Nagarkatti, University of South Carolina

SC EPSCoR/IDeA Program Forward . . . . . Nadim Aziz, SC EPSCoR/IDeA Program

9:30 AM The *New* SCRA . . . . . Bob Quinn, South Carolina Research Authority

9:50 AM **Session 1 – Genetics Research**
Chris Davies, Medical University of South Carolina

The Greenwood Genetic Center – A Privileged Institution . . . . . Charles Schwartz, Greenwood Genetic Center

Analysis of Gene Copy Number Changes in Tumor Phylogenetics . . . . . Jijun Tang, University of South Carolina

Peptide Hormones in Genotype, Phenotype, and Stimuli Control . . . . . Modi Wetzler, Clemson University

10:50 AM Break

11:05 AM **Session 2 - Successful Undergraduate Research Models**
April Heyward, SC EPSCoR/IDeA

Creative Inquiry at Clemson University: Undergraduate Research for All . . . . . Barbara Speziale, Clemson University

Tissue Engineering and Biofabrication Research Experience for Undergraduates (REU) Results . . . . . Jeremy Barth, Medical University of South Carolina

Conducting Research with Undergraduate Colleagues: A Bird of Many Feathers . . . . . John F. Wheeler, Furman University

University of South Carolina Undergraduate Research – Discovery for every discipline . . . . . Julie Morris, University of South Carolina

12:15 PM Lunch

12:40 PM Introduction of Lunch Speaker . . . . . Prakash Nagarkatti, University of South Carolina

NSF: Supporting Research and Education to Benefit the Nation . . . . . Denise Barnes, National Science Foundation

1:30 PM DOE EPSCoR Opportunities . . . . . Tim Fitzsimmons, Department of Energy

1:50 PM **Session 3 – Human-Technology Frontier Research**
Roger Sawyer, University of South Carolina

Human Centered Engineered Systems for Holistic Living . . . . . Rajendra Singh, Clemson University

Controlling Objects Using Signals Emanating from a Human Brain . . . . . Stevo Bozinovski, South Carolina State University

Application of Optimal Sampling Lattices on CT Image Reconstruction and Segmentation or Three-Dimensional Printing . . . . . Xiqiang Zheng, Voorhees College

2:50 PM Break

3:05 PM NASA EPSCoR Opportunities . . . . . Jeppie Compton, NASA KSC

3:25 PM SC EPSCoR/IDeA Stimulus Research Program Solicitation . . . . . April Heyward, SC EPSCoR/IDeA

3:55 PM **Session 4 – Big Ideas**
Doug Hirt, Clemson University

Scientific Results from the Virgin Islands Center for Space Science at Etelman Observatory . . . . . Jon Hakkila, College of Charleston

Quantum and Classical Evolution of Chemical Reaction Wave Front by Fast Marching Method: A New Perspective of Reaction Dynamics . . . . . Bijoy Dey, Claflin University

Optogenetics Datamining in Search for Stable Brain Activity Patterns . . . . . Sorinel A. Oprisan, College of Charleston

4:55 PM Concluding Remarks and Adjourn

Mark Sothmann, State Committee Chair

Mark Sothmann, Ph.D., Provost Emeritus, was named the Vice President for Academic Affairs and Provost at the Medical University of South Carolina in April 2011. From August 2013 through June 2014 Dr. Sothmann served as interim president of MUSC. Dr. Sothmann serves on numerous national academic, science, and health care education advisory boards, and is a Fellow of the American College of Sports Medicine where he has served in leadership roles.

Prakash Nagarkatti State Director

Prakash Nagarkatti, Ph.D., was named the University of South Carolina's Vice President for Research in October 2011. Currently, he oversees a $243 million research enterprise across all USC campuses. He also serves as Carolina Distinguished Professor, Director of the NIH Center of Research Excellence in Inflammatory and Autoimmune Diseases and Director of the NIH COBRE Center for Dietary Supplement and Inflammation. From 2005 through 2011, he served as Associate Dean at the USC School of Medicine.

Denise Barnes Lunch Speaker

Denise M. Barnes, Ph.D., is the Section Head for EPSCoR with NSF. In her role as Section Head, Dr. Barnes oversees NSF EPSCoR program activities to advance excellence in science and engineering research and education in order to achieve sustainable increases in research, education, and training capacity and competitiveness in the 28 EPSCoR Jurisdictions, including South Carolina.

Speaker Abstracts

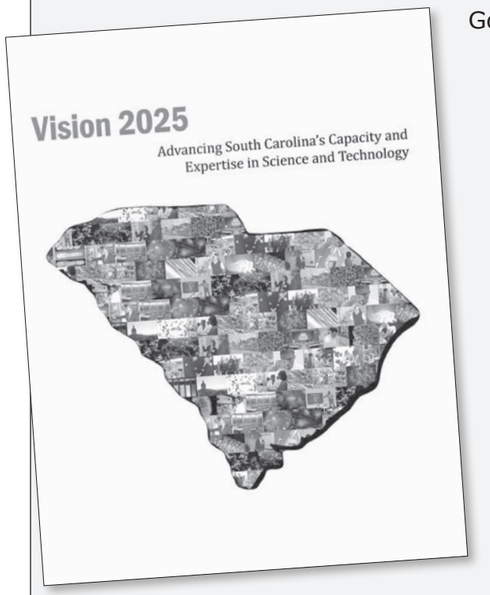
The New SCRA

Bob Quinn (bob.quinn@scra.org), Executive Director, South Carolina Research Authority, Charleston, SC

South Carolina Research Authority (SCRA) recently underwent a major reorganization, which has allowed the organization to have a singular focus on its core mission of fostering South Carolina's Innovation Economy by enabling academic research and its commercialization, assisting entrepreneurs and connecting industry with innovators. Across the state, SCRA supports more than 2600 jobs. The average salary of jobs created by SCRA's Entrepreneurial Program, SC Launch, is $61,870, much higher than the state average of $40,000. There are currently 153 active companies, and many of them are based on academic research.

Bob Quinn, Executive Director of SCRA, will provide insight into new initiatives, such as projects funded under the recently executed SCRA-Academia Strategic Collaboration Agreement, as well as share case studies of the innovation happening in the state.

A long-range vision for South Carolina



Goals:

- SC university and college educational programs and research missions are aligned with the needs of technology-intensive industries within the state and globally.
- SC has an educated and engaged public that understands and participates in the state's health, science and technology research enterprise.
- Individuals having a STEM education from SC are nationally and globally competitive in the health, science, and technology workforce.
- The business environment in SC is attractive to both technology-intensive companies and talented technology-competent workers.

Download a PDF copy of ***Vision 2025*** from the Resources section of our website.

Session 1: Genetics Research

The Greenwood Genetic Center – A Privileged Institution

Charles E. Schwartz (ceschwartz@ggc.org) and Roger E. Stevenson, Greenwood Genetic Center, Greenwood, SC

To us
- ... are entrusted the evaluation and care of thousands of citizens who are touched by hereditary disorders;
- ... have come a talented and diversified faculty and staff'
- ... are given exciting and robust technologies for genetic testing;
- ... come gifted students and trainees who will become our future scientists, physicians and educators;
- ... is provided broad-based support from both the private and public sectors;
- ... is given an era in which much attention and expectation are focused on genetics.

Although research was envisioned to be an essential component of the GGC from its founding in 1974, its research division has become more visible since the opening of the J.C. Self Research Institute of Human Genetics in 1995. Scientists at the Self Research Institute have focused on gaining a greater understanding of intellectual disabilities, birth defects, and autism spectrum disorder, discovering new mechanisms which contribute to disease, and developing new strategies for diagnosis, treatment and prevention. Three research activities highlight these contributions.

X-linked Intellectual Disability. GGC researchers are internationally known for their expertise on genes that cause X-linked intellectual disability, having been involved in the identification of about one-fourth of all known intellectual disability genes located on the X chromosome. Nearly 1000 families from around the world have been included in this research.

Neutral Tube Defects. With the discovery that the B-vitamin folic acid could reduce the risk of severe birth defects of the spine and brain, the GGC established the first statewide program to prevent these birth defects. Through this program, the rate of neural tube defects in South Carolina has decreased over 60% and has been hailed as a model that should exist in every state.

Autism. Research at the GGC related to autism seeks to develop a blood-based test for autism and to develop a medical treatment based on the biochemical profile of children with autism. Over 500 children with autism are participating in this important research.

With its large experienced clinical workforce and capacity in biochemical, cytogenomic and molecular technologies, the GGC is well positioned to advance the Genomes to Phenomes initiative. Application of genomic technologies to understand the 50% of intellectual disabilities, 80% of autism, and 70% of structural birth defects which are currently not resolved at a causal level is a high priority. Fetal alcohol syndrome is among the phenotypes which the GGC plans to investigate from the genomic vantage.

Session 1: Genetics Research

Analysis of gene copy number changes in tumor phylogenetics

Jijun Tang[1] (jtang@cse.sc.edu), Jun Zhou[1], Yu Lin[2], Valihav Rajan[3], William Hoskins[1], Bing Feng[1]

[1]Computer Science and Engineering, University of South Carolina, Columbia, SC, [2]Computer Science, National University of Australia, Canberra, Australia, [3]Xerox Research Centre, Bengaluru, India

Evolution of cancer cells is characterized by large scale and rapid changes in the chromosomal landscape. The fluorescence in situ hybridization (FISH) technique provides a way to measure the copy numbers of preselected genes in a group of cells and has been found to be a reliable source of data to model the evolution of tumor cells. Chowdhury et al. recently develop a computational model for tumor progression driven by gains and losses in cell count patterns obtained by FISH probes. Their model aims to find the rectilinear Steiner minimum tree (RSMT) and the duplication Steiner minimum tree (DSMT) that describe the progression of FISH cell count patterns over its branches in a parsimonious manner. Both the RSMT and DSMT problems are NP-hard and heuristics are required to solve the problems efficiently.

In this paper we propose two approaches to solve the RSMT problem, one inspired by iterative methods to address the "small phylogeny" problem, and the other based on maximum parsimony phylogeny inference. We further show how to extend these heuristics to obtain solutions to the DSMT problem, that models large scale duplication events. Experimental results from both simulated and real tumor data show that our methods outperform previous heuristics in obtaining solutions to both RSMT and DSMT problems. The methods introduced here are able to provide more parsimony phylogenies compared to earlier ones which are consider better choices.

Session 1: Genetics Research

Peptide Hormones in Genotype, Phenotype, and Stimuli Control

Modi Wetzler (mwetzle@clemson.edu), Paris L. Hamilton, Victoria A. Haberman, Jessica M. Cannon, William Weibley, Department of Chemistry, Clemson University, Clemson, SC

While in some cases a genetic mutation leads to a certainty or high likelihood of developing a phenotype (often a disease in humans), in most cases genotype (nature) merely affects propensity that is therefore truly controlled by the environment (nurture). The focus on a phenotype prediction from genotype is governed by the ease of measurement of genotype (sequencing) and success in simple model organisms (e.g., J. Craig Venter Institute's synthetic bacteria via genomic transplantation). For more complex systems and lifeforms, however, such a naïve approach is certain to lead to highly unreliable data unless the complications of stimuli (social, environmental, nutritional, etc.) are incorporated into models at an equally early stage.

We are broadly interested in peptide hormones (e.g., vasopressin, oxytocin, GLP1) that govern social behavior and development. These "social" activities range from the formation of microbial biofilms (surface fouling, degree of pathogenicity) to human aggression and crime. In humans, the peptide hormones play critical roles in pathologies ranging from autism spectrum disorders to neurodegenerative diseases to sexual function and mental health, yet are surprisingly not the subjects of significant pharmaceutical focus in the U.S.

We hope to persuade the attendees to focus not just on the gene-to-function model which is heavily exploited in the literature due to the prevalence of tools to quantify these relationships (genomic, transcriptomic, proteomic data) but to consider the interactions of these systems with environmental cues.

We are also developing tools to enable studying of these types of cues. For example, many of the peptide hormones involved in regulating everything from microbial quorum sensing to mood and behavior in humans have very short half-lives. Longer-lasting analogs that could enable turning these behaviors "on" and "off" could enable (1) more quantitative studies of their effects and interactions with the genome-to-phenome models and (2) more accurate phenotype predictions.

Session 2: Successful Undergraduate Research Models

Creative Inquiry at Clemson University: Undergraduate Research for All

Barbara Speziale (bjspz@clemson.edu), Professor of Biological Sciences and Associate Director, Watt Family Innovation Center, Clemson University, Clemson, SC

Creative Inquiry (CI) is Clemson University's campus-wide undergraduate research program. Begun in 2005, CI enrolls more than 4000 students each year in hundreds of research projects that span all academic disciplines. CI was the basis for Clemson University receiving national recognition in 2016 - the Undergraduate Research Accomplishments Award from the Council on Undergraduate Research.

Clemson's Creative Inquiry offers undergraduate students opportunities for team-based, intensive, discovery-oriented research. In CI, small groups of students work under the direction of faculty mentors. Many projects extend over multiple semesters, thus emulating graduate-school style research experiences. Projects may be within academic disciplinesor multidisciplinary. Support for the student projects is provided by the university or external private and industry donors.

Students praise CI for the opportunities it provides to engage in real-world problem-solving. They report that CI gives them skills that they need to prepare for the workplace, such as learning to work in a team and understanding how to tackle complex issues. Students in CI are also able to develop professional networks, both within the university and among practitioners in their chosen workplace communities.

Students produce valuable work products through Creative Inquiry. Within the university context, such products include more than 600 publications in professional journals and presentations at professional conferences. Products attuned to specific disciplines include architectural models and original art, community programs, engineering installations, and patent disclosures.

This session will describe the Creative Inquiry program, review participation and productivity metrics, provide examples of projects from a wide range of disciplines, and offer advice for other institutions that are starting or expanding their undergraduate research programs.

Session 2: Successful Undergraduate Research Models

Tissue Engineering and Biofabrication Research Experience for Undergraduates (REU) Results

Jeremy Barth (barthj@musc.edu), Medical University of South Carolina, Charleston, SC

Undergraduate research internships can be invaluable experiences for students, providing hands-on training in scientific technical practices, acting as an educational stimulus, and yielding competitive advantages for future academic and professional objectives. The Tissue Engineering and Biofabrication Research Experience for Undergraduates (REU) was a research internship program conducted at the Medical University of South Carolina (MUSC) in the summers of 2013-2016, under the direction of Drs. Scott Argraves and Jeremy Barth. Funded through grants from the **SC EPSCoR Scientific Advocate Network program**, this internship was conducted in collaboration with MUSC researchers pursuing aims thematically linked to the SC Program in Biofabrication funded through a 2009 SC NSF EPSCoR RII grant. Student participants conducted 10-week research projects in the laboratory of an MUSC faculty mentor and participated in numerous educational and enrichment activities that collectively yielded training in laboratory techniques, experimental approach, scientific writing, and oral presentation. Over the four years of execution, this program created 21 training opportunities for undergraduates from six SC institutions and had a URM participation rate of 33%. Of the 12 students that have now completed their baccalaureate degree, six are enrolled in graduate programs, four are employed as biomedical technologists, and two are pursuing medical degrees.

Session 2: Successful Undergraduate Research Models

Conducting Research with Undergraduate Colleagues: A Bird of Many Feathers

John F. Wheeler (john.wheeler@furman.edu), Office of Integrative Research in the Sciences, Furman University, Greenville, SC

Evolution of cancer cells is characterized by large scale and rapid changes in the chromosomal landscape. The fluorescence in situ hybridization (FISH) technique provides a way to measure the copy numbers of preselected genes in a group of cells and has been found to be a reliable source of data to model the evolution of tumor cells. Chowdhury et al. recently develop a computational model for tumor progression driven by gains and losses in cell count patterns obtained by FISH probes. Their model aims to find the rectilinear Steiner minimum tree (RSMT) and the duplication Steiner minimum tree (DSMT) that describe the progression of FISH cell count patterns over its branches in a parsimonious manner. Both the RSMT and DSMT problems are NP-hard and heuristics are required to solve the problems efficiently.

In this paper we propose two approaches to solve the RSMT problem, one inspired by iterative methods to address the “small phylogeny” problem, and the other based on maximum parsimony phylogeny inference. We further show how to extend these heuristics to obtain solutions to the DSMT problem, that models large scale duplication events. Experimental results from both simulated and real tumor data show that our methods outperform previous heuristics in obtaining solutions to both RSMT and DSMT problems. The methods introduced here are able to provide more parsimony phylogenies compared to earlier ones which are consider better choices.

Session 2: Successful Undergraduate Research Models

University of South Carolina Undergraduate Research – Discovery for every discipline

Julie Morris (jmorris@sc.edu), Director, Office of Undergraduate Research, University of South Carolina, Columbia, SC

Undergraduate research is an essential component to educating students for success throughout their academic career and beyond. The University of South Carolina recognizes that one size does not fit all in the quest to develop life-long learners and future leaders. We are committed to providing opportunities for students in all disciplines and backgrounds to engage in learning and gain hands-on experience in their field of interest across the state system – to find and live their passion. To do this, USC has developed strong and intentional undergraduate research partnerships within the system (through institutional programs and grant awards) as well as across the state (such as the Alliance for Minority Participation network of HBCUs and technical colleges). Strategic partnerships were established to support our historically underserved students, particularly first generation and Hispanic students, who often achieve greater gains through participation in high impact practices (higher grades, persistence, and retention) but are often the least likely to participate (Nagda et al., 1998; Kuh, 2008; Kuh, O'Donnell, & Reed, 2013; Finlay & McNair, 2013). The impact of these partnerships is to create a variety of experiences meeting the needs of a diverse student body.

Key highlights tinclude:

- TRIO Programs including the McNair Scholars Program: As partners, we encourage early research experiences, provide targeted grant funding, and facilitate extended research for McNair Scholars.
- The SC Alliance for Minority Participation: Through this program, we provide summer research and professional development experiences for minority students in STEM with an emphasis in supporting students on the path to graduate school. This network creates a framework for partnerships with state HBCUs and technical colleges.
- The Summer Community of Scholars: This initiative brings together the above with externally funded summer programs (including REUs, Center for Colon Cancer Research Summer Undergraduate Minority Research Program, and NIH SC-Advancing Diversity in Aging Research Program) and individual scholars engaged in projects across campus. This program provides enhancement experiences such as summer workshops and a poster symposium to support common experiences for students and resources for faculty.
- The Magellan Programs: As USC's signature programs for facilitating faculty-mentored student research, Magellan consists of eight grant programs plus peer leadership opportunities supporting students through all stages of their research journey from first steps to advanced scholars. The success of these programs rely on institutional partner support.
- Showcasing initiatives: As the culminating step for undergraduate researchers, USC has two venues for students to highlight their accomplishments: Caravel, the on-line research journal, and Discover USC, the system conference for research and scholarly initiatives.

USC is committed to supporting research experiences across disciplines, across institutional types within our system campuses and most especially within special populations. The strength of the partnership model approach is that its implementation is adaptable and sustainable across institutional types and campus climates. The institutional culture of research shaped through these partnerships, introduces research early in students' academic careers; provides opportunities to engage in a variety of disciplines; offers funding and independent study options for participation; and creates avenues to showcase achievements, along with the flexibility needed to meet the educational goals necessary for a diverse student body.

Session 3: Human-Technology Frontier Research

Human Centered Engineered Systems for Holistic Living

Rajendra Singh[1, 2], Ganesh Kumar Venayagamoorthy[1, 2], Guneet Bedi[1], Mashrur Chowdhury[3], Ilya Safro[4], Amy Apon[4], D. Matthew Boyer[5], Cheryl J. Dye[6], Simona Onori[2], Prasad R. Rangaraju[3], Richard Brooks[1], Yongquing Wang[1], Kuang-Chang Wang[1], Melissa C. Smith[1], and Michael Carbajales-Dale[7]

[1]Holcombe Department of Electrical and Computer Engineering, [2]Department of Automotive Engineering, [3]Glen Department of Civil Engineering, [4]School of Computing, [5]Department of Education and Human Development, [6]School of Health Research, [6]Glen Department of Civil Engineering, [7]Department of Environmental Engineering and Earth Sciences, Clemson University, Clemson, SC

Hardware and software developments have played a vital role in enabling the revolution that started in the last half of the 20th century and has provided the capability of "personal communication." Fossil fuels based power generation has dominated the last century. In recent years, solar and wind as clean energy sources have started to account for most new global electricity generating capacity. With the improvement in technology and volume manufacturing, the cost of batteries is constantly falling and leading to a phenomenal growth of electric vehicles. The local power network based on clean energy will provide resilient, reliable and sustainable power source to everyone leading to "personal power." A key new component in personal transport is mobility as a service. The implementation of autonomous vehicles based "personal mobility," will provide improved quality of life to the aged population of our society. The use of sensors, actuators, and relays in the internet of things (IoT) coupled with the advancements in real-time intelligent control of information, power and computing are allowing us to build a new generation of human-centered engineered systems (HCES). An example of such HCES is that when the rider enters in an autonomous vehicle, the body mass index is communicated to the rider on his/her personal communication device. The combination of "personal communication," "personal power," and "personal mobility" is paving the way for holistic living. The positive health effects of holistic living will save many billions of dollars of health cost our nation pays per year. Behavioral changes and changes in social attitudes are necessary to realize the full potential of new HCESs. The interactions of our engineering students with social and health science students will educate a new generation of future leaders who will learn real world environment while being a student on campus. The emergence of "personalization and precision" will be the driver of the emergence of HCES in the 21st century. In addition to providing the science and technology of HCES for holistic living that will provide transformative opportunities to urban and rural population all over the world, the economic development related to South Carolina will be covered.

Session 3: Human-Technology Frontier Research

Shaping the new human-technology frontier: Controlling objects using signals emanating from a human brain

Stevo Bozinovski (sbozinovski@scsu.edu), Liljana Bozinovska, South Carolina State University, Orangeburg, SC

It was an old dream of people to move physical objects using energy emanating from human brain. It science fiction literature it was named psychokinesis. It was not until 1988 when two people, authors of this abstract, succeeded to use electromagnetic energy emanating from human brain if form of EEG signals, to control a physical object, a mobile robot. The event took place at Laboratory for Intelligent Machines and Bioinformation Systems, of Electrical Engineering Department, in Skopje, Macedonia. At that time we were not aware that we are doing a pioneering work. We were just following our ideas. Now the first reports of that event [1][2] are evidence of a pioneering result in the area of brain computer interface [3]. The approach and algorithms used are described in [2][4].

Thanks to the support of EPSCoR we continued our research in South Carolina State University in 2005. The title of SCSU grant was “Research Infrastructure Improvement for Neuroscience and Brain-Computer Interface at SCSU”. In 2009 we received another grant for “Research Infrastructure Improvement fir Master’s Program in Biorobotics and Biofabrication”. With such support we were able to produce another pioneering result, EEG emulation of digital control circuits [5].

Objective of our further research is to design a low cost Brain Computer Interface control device for help people with disabilities. We will use methods we used so far which are based on EEG demultiplexer and EEG modem. However we will explore other methods too. Various applications will be considered, like writing a text on a screen, controlling movement of an object on a screen, and controlling physical objects (doors, TVs, robots, prostheses, etc).

1. Bozinovski, S., Sestakov, M., Bozinovska, L. (1988) Using EEG alpha rhythm to control a mobile robot. In: G. Harris, C. Walker (eds.) Proceedings of 10th Annual Conference of the IEEE Engineering in Medicine and Biology Society, New Orleans, LA, vol. 10, pp. 1515–1516, track 17: Biorobotics
2. Bozinovski, S. (1990) Mobile robot trajectory control: from fixed rails to direct bioelectric control. In: O. Kaynak, (ed.) Proceedings of IEEE International Workshop on Intelligent Motion Control, Istanbul, Turkey, vol. 2, pp. 463–467
3. Wikipedia: Brain Computer Interface, paragraph three. Viewed March 2017
4. Bozinovski, S. (2013) Controlling robots using EEG signals, since 1988. In S. Markovski, M. Gusev (eds.) ICT Innovations 2012, Springer Verlag, p. 1-11
5. Bozinovski, S., Bozinovski, A. (2015) Mental states, EEG manifestations, and mentally emulated digital circuits for brain-robot interaction. IEEE Trans. Autonomous Mental Development 7(1), 39–51

Session 3: Human-Technology Frontier Research

Application of optimal sampling lattices on CT image reconstruction and segmentation or three dimensional printing

Xiqiang Zheng (xzheng@voorhees.edu), Voorhees College, Denmark, SC

The usual computations are done on a Cartesian lattice for discretization of geometric objects. However optimal sampling lattices, such as 2D hexagonal and 3D face centered cubic (FCC) and body centered cubic (BCC) lattices, provide more efficient sampling than Cartesian lattices. The optimal sampling lattices have higher packing density of disks or balls than Cartesian lattices. Furthermore, the neighbors of each lattice point in a hexagonal or FCC lattice are equidistant from the lattice point. Hence optimal sampling lattices provide better X-ray CT (computed tomography) image reconstruction and segmentation results.

In image reconstructions by way of fast Fourier transforms (FFTs) or filtered backprojection (FB) algorithms, the samples of frequencies lie on a polar grid and in a circular region. To apply an inverse FFT or FB algorithm, the previous CT image reconstruction methods are to interpolate samples of frequencies into a square region. Because a circle can be embedded into a regular hexagon more tightly than into a square, better image reconstruction and segmentation effects may be achieved if we interpolate the polar grid samples into a hexagonal region instead of a square region. Therefore, in this research, we will try to improve the previous image reconstruction and segmentation methods. Especially we will apply both optimal sampling lattices and efficient domains for two and three dimensional CT image reconstruction and segmentation.

Because of higher packing densities, optimal sampling lattices may also be applied to some 3D printing tasks such as 3D ceramic printing to produce a firmer object with smoother surface. We may develop efficient computer algorithms for 3D printing utilizing optimal sampling lattices.

Session 4: Big Ideas

Scientific Results from the Virgin Islands Center for Space Science at Etelman Observatory

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We present results of our NASA EPSCoR project to improve and further develop the Etelman Observatory telescope on the island of St. Thomas in the US Virgin Islands. The rapid-slewing 0.5 m Etelman Observatory telescope is at a unique longitude between the US East Coast and the South American West Coast. We demonstrate the observatory's effectiveness with, among other things, an image of a gamma-ray burst afterglow having a red magnitude of 20.8 (GRB170202A). Science results from the successful EPSCoR project extend beyond observations obtained at Etelman, and include satellite data analysis of GRB prompt emission. Results of these analyses include the discovery that GRB pulses (the basic units of GRB prompt emission) have triple-peaked structures characterized by hard to soft evolution. These pulse structures have been observed in GRBs detected across multiple instruments onboard the Swift, Fermi, and Compton Observatory satellites, and are present in all GRB classes (Long, Short, and Intermediate). These pulse structures have also been identified in the x-ray flares accompanying GRB afterglows, indicating that the mechanism can produce low energy pulses long after the prompt emission has ended. The still unknown mechanism that produces GRB pulses apparently works over a tremendous range of energies, time scales, and with different presumed progenitors. Funding from this project has also supported the discovery of some of the largest structures in the universe; the locations of these giant filamentary strands of galaxies have been identified by clustered, luminous GRBs embedded within them. Plans for future research by the science team will place Etelman in the time-domain astronomy context, with first light of LSST rapidly approaching. In addition to GRB afterglows, Etelman observing time will also address exoplanets, tidal disruption, superluminal supernovae, and the search for electromagnetic counterparts to gravitational wave events. The team will also continue to study GRB pulses and x-ray afterglow flares to explain the physical mechanism and conditions responsible for them.

Session 4: Big Ideas

Quantum and Classical Evolution of Chemical Reaction Wave-Front by Fast Marching Method: A new perspective of reaction dynamics

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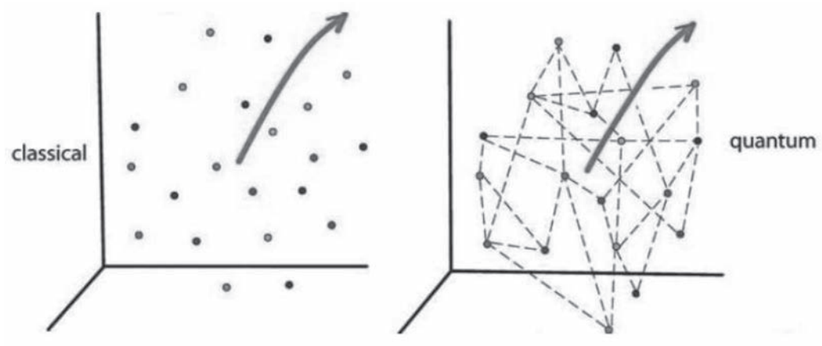
The field of chemical reaction dynamics inherently depends on the reaction paths providing a detailed atomistic description of a reaction. Although classical mechanics is widely applied by theoretical chemists, we seek to explore a new method which allows some quantum aspect to be brought back to the classical description. The method relies on the hydrodynamical formulation of Schrödinger equation initially proposed by de Broglie and Bohm. This leads to a continuity equation (1) and a quantum Hamilton-Jacobi equation (2)

$$\frac{\partial \rho}{\partial t} = -\nabla\left(\rho \frac{\nabla S}{m}\right) \qquad (1)$$

$$-\frac{\partial S}{\partial t} = \frac{(\nabla S)^2}{2m} + V_{cl} + V_{qu} \qquad (2)$$

The term V_{qu} (quantum potential, which depends explicitly on $\hbar$) is responsible for the nonlocality, a pure quantum characteristics. Without the V_{qu} term, the entire system is classical which then allows trajectories (classical) to move independently (Fig.1a). The V_{qu} term brings back the correlation among the trajectories (Fig. 1b). In the above equations, ρ is the probability amplitude (related to particle distribution in the sense of statistical ensembles), S is the phase function which reduces to Hamilton's characteristic function of classical mechanics in the limit $\hbar \to 0$, V_{cl} is the potential energy that defines the reaction system, and V_{qu} is the quantum potential.



Our research focus is in solving the classical HJ equation ($V_{qu} = 0$, $\hbar \to 0$) for various reactions described by their potential energy surfaces (PES) followed by introducing V_{qu} at different order of $\hbar$. We have employed Fast marching method (FMM) to solve the HJ equation, which replaces PES by a chemical reaction wave-front (CRWF). The CRWF offers means to analyze the reaction paths between two different states in the PES.

We will discuss the FMM, classical HJ equation, the newly defined CRWF and the reaction paths with reference to several important chemical reactions, such as a model four-well potential, SN2 reaction and H-transfer in malonaldehyde. The means and effect of introducing quantum tpotential on the CRWF and the reaction paths will be also discussed during the talk.

Session 4: Big Ideas

Optogenetics datamining in search for stable brain activity patterns

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Introduction. Gamma oscillations show strong coherence across different areas of the brain during associative learning or during successful recollection. Gamma rhythm involves the reciprocal interaction between interneurons, mainly parvalbumin (PV+) fast spiking interneurons (FS PV+) and principal cells. The predominant mechanism for neuronal synchronization is the synergistic excitation of glutamatergic pyramidal cells and GABAergic interneurons. Nonlinear time series was previously used for investigating large-scale synchronization of activity that leads to epilepsy was diagnosed using nonlinear dynamics and for disrupting synchronization based on phase response curve.

Method. We used optogenetic mice to record the local field potentials (LFPs) from medial prefrontal cortex (mPFC) in response to 473 nm laser light stimuli. We used a single, 10 ms duration, light pulse applied every 2 s and recorded with a sampling time $\Delta t = 10^{-4}$ s. Each trial was repeated 100 times and we only retained and analyzed data from six animals that showed stable and repeatable response to optical stimulations. For each trail, surrogate data sets were generated and both time reversal asymmetry and false nearest neighbor (FNN) were used as discriminating statistics for the null hypothesis. We used the delay embedding method to investigating the possibility of recovering phase resetting from single-cell recordings.

Results. We used average mutual information to determine the delay time and FNN to estimate the embedding dimension. Although the shape of the attractors for control group were relatively stable and similar, we found significant changes under systemic amphetamine administration. Under amphetamines, the autocorrelation function gave a significantly smaller delay time for attractor embedding. This also correlates with a decrease in LFP noise under amphetamine.

Future research. While phase space reconstruction offers a glimpse into the possible brain activity patterns and how they change under different pharmacological conditions, we are more interested in modeling and controlling such patterns. The next step in our research is the design of a mathematical model based on our data.

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