

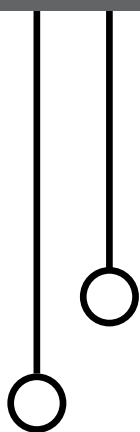
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RESEARCH

2022 – 23

NC State is one of six universities nationwide to become part of a five-year \$20M grant from the National Science Foundation (NSF) and the U.S. Department of Agriculture's (USDA) National Institute of Food and Agriculture (NIFA) to lead a new National Artificial Intelligence Research Institute. NC State's portion of the grant is \$500,000, and the lead researcher on the project is computer science professor **Dr. Raju Ranga Vatsavai**.

Researchers at the **AI Institute for Climate-Land Interactions, Mitigation, Adaptation, Tradeoffs and Economy (AI-CLIMATE)** aim to leverage artificial intelligence (AI) to create more climate-smart practices that will absorb and store carbon while boosting the economy in the agriculture and forestry industries.



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As a Tier 1 research institution, research is fundamental to what we do in the Department of Computer Science here at NC State University. Our faculty are widely recognized as leaders in their fields conducting impactful and pertinent research. We have had 34 National Science Foundation (NSF) CAREER Award recipients, to date, as well as 10 Institute of Electrical and Electronics Engineers (IEEE) Fellows, three IEEE Golden Core members, three Association for Computing Machinery (ACM) Fellows, and two American Association for Artificial Intelligence Fellows. Additionally, we have numerous recipients of NC State's top research and mentorship award — the Outstanding Research Award — who are also members of NC State's Research Leadership Academy. We even have a member of the National Inventor's Hall of Fame, and a recipient of an Emmy Award from the National Academy of Television Arts and Sciences!

As you may know, two years ago the State of North Carolina recognized the significant growth of science, technology, engineering and mathematics (STEM) workforce-dependent industries in our state, allocating \$20M to launch the Engineering North Carolina's

Future initiative. As a result, we have not only seen significant growth in our enrollments, but we've made double-digit faculty additions for the second year in a row.

As our department continues to grow, we will continue to add more tenure-track faculty and teaching professors. With these new faculty members and students, we will be able to increase the strength of our research and educational offerings. This expansion will further secure CSC's position as the preeminent computer science department in North Carolina, and one of the strongest departments in the nation.

We are also happy to report that we are taking significant action to address the adverse impact that inflation has had on our graduate students. A plan was recently approved to increase monthly TA stipends by \$300 per month in stages between now and August 2024.

The department's research productivity continues to reach record levels of support with more than \$15 million in new awards, and annual expenditures in the \$15.5 million range.

Continued on page 3

Research Highlights

Listed below are brief synopses of some of the most notable research projects currently underway in the NC State Computer Science Department. For more information on the department's research activities, please visit csc.ncsu.edu/research.

NC State University is one of six universities nationwide to become part of a five-year \$20M grant from the National Science Foundation (NSF) and the U.S. Department of Agriculture's (USDA) National Institute of Food and Agriculture (NIFA) to lead a new National Artificial Intelligence Research Institute. NC State's portion of the grant is \$500,000, and the lead researcher on the project is Computer Science professor **Dr. Raju Ranga Vatsavai**.

Led by the University of Minnesota Twin Cities, researchers at the **AI Institute for Climate-Land Interactions, Mitigation, Adaptation, Tradeoffs and Economy (AI-CLIMATE)** aim to leverage artificial intelligence (AI) to create more climate-smart practices that will absorb and store carbon while simultaneously boosting the economy in the agriculture and forestry industries. Using new AI techniques like deep learning and knowledge-guided machine learning, researchers at the AI-CLIMATE institute are improving accuracy and lowering the cost of accounting for carbon and greenhouse gases in farms and forests, ultimately making the process more accessible for more people. The Institute will also expand and diversify rural and urban AI workforces.

Dr. Thomas Price, Assistant Professor of Computer Science and Director of the HINTS lab at NC State, is part of a team called the Adaptive Experimentation Accelerator, that won the \$500,000 grand prize in the **XPRIZE Digital Learning Challenge**. Launched in 2021, the Digital Learning Challenge is a global competition that incentivized teams to modernize, accelerate and improve technology and processes for evaluating and measuring effective learning and education. Price and the team developed a tool that allows educators to conduct experiments in the classroom to determine which teaching methods are most effective.

Dr. Noburo Matsuda, Associate Professor of Computer Science, and other researchers have developed an artificial intelligence (AI) model that can generate online course assessment questions that instructors found indistinguishable from questions written by humans. The new AI is called **QUADL**, and it does two things: it identifies key terms and ideas in instructional texts, and then crafts questions that focus on those terms and ideas. The researchers provide QUADL with the courseware contents and the learning objectives for the curriculum, and QUADL can then develop questions that help students achieve those learning objectives.

Dr. James Lester, Goodnight Distinguished University Professor in Artificial Intelligence and Machine Learning, and research scientist **Wookhee Min**, along with Ph.D. student **Jay Pande**, have developed a new artificial intelligence (AI) framework that is better than previous technologies at analyzing and categorizing dialogue between individuals, with the goal of improving team training technologies. The framework will enable training technologies to better understand how well individuals are coordinating with one another and working as part of a team.

Despite attempts to anonymize user data, the fitness app Strava allows anyone to find personal information — including home addresses — about some users. The finding, which is detailed in a new study, raises significant privacy concerns. Mobile fitness-tracking apps such as Strava are commonly used to record activities, track fitness progress and form a community with like-minded people. In an

effort to engage the community further, in 2018 Strava implemented an optout heatmap feature that anonymously aggregates all activities onto a single map. This allows users to find hot spots and active trails while simultaneously opening up the platform to deanonymization attacks like inferring users' home addresses. Researchers led by **Dr. Anupam Das**, Assistant Professor of Computer Science, have demonstrated that the home address of highly active users in remote areas can be identified, violating Strava's privacy claims and posing as a threat to user privacy.

The latest weapon in the war on robocalls is an automated system capable of analyzing the content of these unsolicited bulk calls to shed light on both the scope of the problem and the type of scams being perpetuated by robocalls. The tool, called SnorCall, is designed to help regulators, phone carriers and other stakeholders better understand and monitor robocall trends — and take action against related criminal activity. **Dr. Bradley Reaves**, Associate Professor of Computer Science, and other researchers at NC State have developed a tool that allows them to characterize the content of robocalls, and they've done so without violating privacy concerns. They collaborated with a Computer Science Department ePartner telecommunications company called Bandwidth to operate more than 60,000 phone numbers that are used solely to monitor unsolicited robocalls.

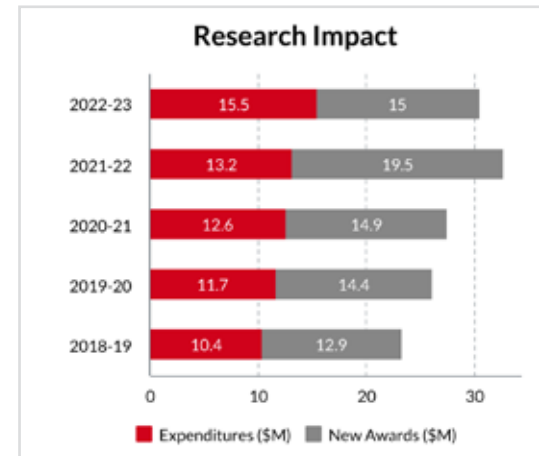
Nowadays, a wristwatch can track your heart rate, measure your blood oxygen level and even give you an electrocardiogram test (commonly abbreviated as "EKG" or "ECG"). And plenty of pet owners probably wish they could afford to track their furry friend's health in real-time the same way, too. Thanks to Drs. **David Roberts** and **Alper Bozkurt**, maybe one day they can. Roberts, an Associate Professor in the Department of Computer Science, and Bozkurt, a Distinguished Professor in the Department of Electrical and Computer Engineering, have developed an algorithm that can monitor cardiac activity in dogs — consistent with an EKG — using inertial sensors already employed in pet activity trackers available on the market today. Their software enables EKG measurement via existing low-cost, generic hardware. All of this means you might be able to eventually keep much better track of your canine companion's heart health just by attaching an affordable device to their collar. Their project is one of six projects that secured support from the Chancellor's Innovation Fund (CIF) this year, and for the first time in CIF's history, awardees will receive supplemental resources through local entrepreneur and investor Bill Spruill's 2ndF Research Commercialization Fund.

Dr. Jianqing Liu, Assistant Professor of Computer Science, was recently awarded a \$1.1 million grant by the National Science Foundation (NSF) for his project "Quantum-Enhanced Optical Diagnosis of Crop Diseases." NC State has never had a winning project... until now. Liu's passion for quantum research led him to start his own project aimed at plant health in North Carolina, and combating what he calls "a headache" in the agriculture industry: downy mildew. Downy mildew is a plant disease that infects the plant leaves and kills them at a rapid rate. Once infected, it takes around four to five days to become detectable, which in most cases is too late. To treat the mildew, fungicides are used, which are not environmentally friendly. Liu's project is aimed at shortening the detection time of four to five days down to one to two days, giving plants a greater chance of survival and maintaining these ecosystems.

Research expenditures for the 2022-23 academic year were up 17% from the 2021-22 (\$13.2M), up 23% over 2020-21 (\$12.6M), up 32% over 2019-20 (\$11.7M), and up 49% over 2018-19 (\$10.4M).

New research awards exceeded \$15M for the second year in a row. While down from 2021-22 (\$19.5M), last year was a record-breaking year with several large new awards, including the \$6M National Science Foundation (NSF) grant to help establish the Secure Software Supply Chain Center (S3C2), and the \$2M grant from the National Centers for Academic Excellence in Cybersecurity to support the North Carolina Partnership for Cybersecurity Excellence (NC-PaCE). Compared to years prior to 2021-22, new award funding in 2022-23 was up 0.5% over 2020-21 (\$14.9M), and up 4% over 2019-20 (\$14.4M), and up 44% over 2018-19 (\$10.4M).

Some of our 2022-23 research highlights are listed on **page 2** and a sampling of some of our research projects appears on **page 4** of this newsletter. Please visit our website (csc.ncsu.edu) to learn more about the department, our faculty and staff, and our cutting-edge research.



Here are some other research highlights and prestigious honors, awards and professional accomplishments by our faculty that deserve special recognition:

- Thomas Price**, assistant professor of computer science, is part of a team called the Adaptive Experimentation Accelerator that won the \$500,000 grand prize in the XPRIZE Digital Learning Challenge.
- James Lester** has been named the inaugural Goodnight Distinguished University Professor in Artificial Intelligence and Machine Learning. Lester is also director of the National Science Foundation AI Institute for Engaged Learning led by NC State and our Center for Educational Informatics.



- Munindar Singh** has been named the SAS Institute Distinguished Professor of Computer Science. He was previously named an Alumni Distinguished Graduate Professor in the Department of Computer Science.
- Donald Bitzer**, Distinguished University Research Professor of Computer Science, has been named a 2022 Fellow by the Computer History Museum for his global influence and outstanding contributions in the field of computer science.
- Rada Chirkova**, professor of computer science, was named a 2022 Distinguished Member of the Association for Computing Machinery (ACM) for her outstanding scientific contributions to computing.
- Zhhishan Guo**, associate professor of computer science, has won a 2023 ACM Special Interest Group on Embedded Systems (ACM SIGBED) Early Career Award.
- Ph.D. student **Jay Pande** has been chosen to receive a prestigious and highly competitive National Science Foundation (NSF) Graduate Research Fellowship. His research interests focus on using artificial intelligence to support adaptive learning environments that embrace principles of universal design for learning.
- Ph.D. student **Mark Abdelshiheed** was named the 2022-23 NC State University College of Engineering Doctoral Scholar of the Year. His research interests lie in the areas of cognitive science and artificial intelligence in education.

Finally, preparing well-educated students for the workforce is also key to the mission of the department. Our enrollment continues to increase. In fall 2023, we enrolled over 2,670 students in the department — 1,785 undergraduates and 887 graduate students (233 Ph.D. students). In 2022-23 we awarded 292 undergraduate and 414 graduate degrees. Demand for our graduates continues to remain high with annual salaries for our undergraduates averaging over \$87,500 / year, and M.S. graduates averaging more than \$120,000. It's even higher for our Ph.D. graduates. We are one of the top suppliers of new grad talent to companies like IBM, Cisco Systems, NetApp, SAS Institute and other top financial and IT organizations, as well as other high-tech companies.

In conclusion, I would like to thank you for your continued support of computer science at NC State. We hope you will stay connected with the department through our website, social media channels and our departmental publications.

Gregg Rothermel
Professor and Department Head

Selected Research Projects

AI Institute for Engaged Learning, **James Lester**. \$19,996,290 by **National Science Foundation**.

Enabling a Secure and Trustworthy Software Supply Chain, **Laurie Williams, William Enck, Alexandros Kapravelos**. \$6,344,481 by **National Science Foundation**.

Science and Technologies for Phosphorus Sustainability (STEPS) Center, **Jacob Jones, Rada Chirkova**. \$4,999,334 by **National Science Foundation**.

National Center of Academic Excellence in Cybersecurity (NC State), **Laurie Williams, William Enck**. \$2,981,264 by **National Security Agency**.

A Cybersecurity Educational Partnership for the Government Workforce, **Douglas Reeves, Sarah Heckman**. \$2,748,558 by **National Science Foundation**.

Tools for Natural Language-Based Team Communication Assessment and Team Feedback in Collective Synthetic Training Environments, **James Lester, Bradford Mott, Jonathan Rowe, Randall Spain**. \$2,018,810 by **U.S. Army — Army Research Laboratory**.

Generalizing Data-Driven Technologies to Improve Individualized STEM Instruction by Intelligent Tutors, **Min Chi, Tiffany Barnes, Thomas Price**. \$1,999,578 by **National Science Foundation**.

Improving Conceptual Knowledge in Upper Elementary Science with Scaffolded Sketch-Based Modeling, **James Lester, Bradford Mott**. \$1,999,050 by **US Department of Education (DED)**.

Transforming Introductory Computer Science Instruction with an AI-Driven Classroom Assistant, **Bita Akram, James Lester, Bradford Mott, Jessica Vandenberg**. \$1,723,467 by **National Science Foundation**.

Improving Student Learning with Explanation-based Classroom Response Systems, **James Lester, Wookhee Min**. \$1,599,645 by **National Science Foundation**.

A Personalized Wearable Rehabilitation Sensing System for Stroke Survivors, **Yong Zhu, Xiaogang Hu, Alper Bozkurt, Xu Liu, Xipeng Shen**. \$1,199,998 by **National Institutes of Health**.

Engaging Rural Students in Artificial Intelligence to Develop Pathways for Innovative Computing Careers, **Bradford Mott, Wookhee Min, Veronica Cateté**. \$1,166,886 by **National Science Foundation**.

NSF Quantum Leap Challenge Institute for Robust Quantum Simulation, **Frank Mueller, Gregory Byrd, Huiyang Zhou**. \$1,125,000 by **University of Maryland, College Park**.

Real-time Analytics to Monitor and Predict Emerging Plant Disease, **Jean Ristaino, Ignazio Carbone, Peter Ojiambo, Christopher Jones, Raju Vatsavai**. \$1,000,000 by **National Science Foundation**.

Virtual Quantum Networks: From Foundation to Field Tests, **Jianqing Liu**. \$800,000 by **National Science Foundation**.

Defending Against Emerging Stateless Web Tracking, **Alexandros Kapravelos, Anupam Das**. \$799,081 by **National Science Foundation**.



Day-Ahead Probabilistic Forecasting of Net-Load and Demand Response Potentials with High Penetration of Behind-the-Meter Solar-plus-Storage, **Xipeng Shen, Wenyuan Tang**. \$750,000 by **U.S. Department of Energy (DOE) — Energy Efficiency and Renewable Energy (EERE)**.

Catalyzing Action-Oriented Academic Communities for Broadening Participation in Computing, **Tiffany Barnes, Veronica Cateté**. \$652,289 by **National Science Foundation**.

Agricultural Decision Intelligence Modeling System for Human-AI Collaborative Action Elicitation and Improvement (DECIDE-SMARTER), **David Roberts, Michael Kudenov, Cranos Williams, Daniela Jones, Sarah Barnhill**. \$648,722 by **U.S. Department of Agriculture — National Institute of Food and Agriculture**.

Software-Tailored Architecture for Quantum Co-Design, **Frank Mueller, Huiyang Zhou, Alexander Kemper**. \$623,408 by **Duke University**.

CAREER: Increasing Trust and Reducing Abuse in Telephone Networks, **Bradley Reaves**. \$606,848 by **National Science Foundation**.

CAREER: Algorithmic Aspects of Pan-genomic Data Modeling, Indexing and Querying, **Sharma Thankachan**. \$603,271 by **National Science Foundation**.

Enabling Practically Secure Cellular Infrastructure, **William Enck**. \$601,966 by **National Science Foundation**.

Socially Relevant Computing and Analytics, **Tiffany Barnes, Collin Lynch, Veronica Cateté**. \$598,913 by **National Science Foundation**.

CAREER: Web Evolution and Emerging Threats, **Alexandros Kapravelos**. \$561,188 by **National Science Foundation**.

Engaging Female High School Students in New Frontiers of Computing, **Tiffany Barnes**. \$555,000 by **National Science Foundation**.

Using Fine-Grained Programming Trace Data to Inform Disciplinary Models of Self-Regulated Learning in Computing Education, **Thomas Price**. \$525,284 by **National Science Foundation**.

CAREER: WolfPack: An Application-Network Co-Design Framework for Performance-Guaranteed Real-time Applications at the Network Edge, **Ruozhou Yu**. \$505,702 by **National Science Foundation**.

Foundations of Ethics for Multiagent Systems, **Munindar Singh**. \$500,000 by **National Science Foundation**.

CAREER: On the Foundations of Semantic Code Search, **Kathryn Stolee**. \$500,000 by **National Science Foundation**.

Formative Feedback for Writing, **Collin Lynch**. \$499,973 by **Education Testing Service**.

Detecting Vulnerabilities and Remediations in Software Dependencies, **William Enck, Bradley Reaves**. \$499,928 by **National Science Foundation**.

Towards the Development of a Customizable Fleet of Autonomous Co-Robots for Advancing Aquaculture Production, **Sierra Young, Steven Hall, John-Paul Ore, Celso Castro-Bolinaga, Natalie Nelson**. \$499,245 by **U.S. Department of Agriculture — National Institute of Food and Agriculture**.

CAREER: Taming Wireless Devices Cross-Layer Errors with Assistive Networked Edges, **Jianqing Liu**. \$447,106 by **National Science Foundation**.



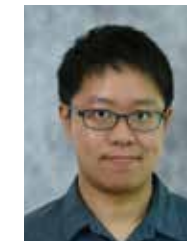
Wesley K.G. Assunção has joined the department as an Associate Professor. His research interests are in AI and machine learning for software engineering, model-driven software reuse and variability, software modernization, software quality, software testing and collaborative engineering. He received his Ph.D. in 2017 from Federal University of Paraná, Brazil.



Caio Batista de Melo has joined the department as an Assistant Teaching Professor. His research interests are in reliable systems, emergent behaviors and computer science education. He received his Ph.D. in 2023 from the University of California, Irvine.



Abida Haque has joined the department as an Assistant Teaching Professor. Her research interests are in cryptography, digital signatures and the theory of algorithms. She received her Ph.D. in 2023 from NC State University.



Chin Ho Lee has joined the department as an Assistant Professor. His research interests are in theoretical computer science - computational complexity theory, randomness in computing, analysis of Boolean functions and statistical reconstruction. He received his Ph.D. in 2018 from Northeastern University.



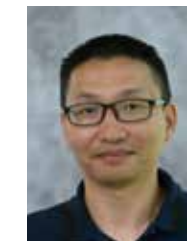
Sharath Raghvendra will join the department next semester as an Associate Professor. His research interests are in algorithm design, geometric optimization, optimal transport theory and its applications to machine learning, online algorithms and topological data analysis. He received his Ph.D. in 2012 from Duke University.



Chandrika Satyavolu has joined the department as an Associate Teaching Professor. Her research interests are in active learning techniques to improve student engagement, summer intervention programs to support student preparedness for college, and wireless and mobile networks. She received her Ph.D. in 2014 from the University of Oklahoma, Norman.



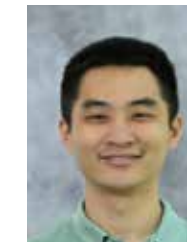
Kimberly Titus has joined the department as an Associate Teaching Professor. Her research interests are in computer science and data science education, developing tools and tutorials to improve programming instruction and undergraduate performance, data literacy and effective uses of chatbots in education. She received her Ph.D. in 1994 from NC State University.



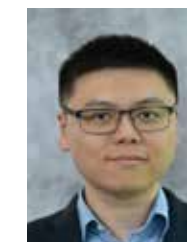
Wujie Wen has joined the department as an Associate Professor. His research interests are in software-hardware co-design for efficient domain-specified computing, design automation and hardware acceleration, trustworthy and privacy-preserving AI computing, machine learning, and cyber-physical systems. He received his Ph.D. in 2015 from the University of Pittsburgh.



Dominik Wermke has joined the department as an Assistant Professor. His research interests are in usable security, supporting software experts, the software supply chain and the open source ecosystem; designing secure and user-friendly systems; and improving collaboration and security in open source communities. He received his Ph.D. in 2023 from Leibniz University, Hannover, Germany.



Bowen Xu has joined the department as an Assistant Professor. His research interests are in large language model of code, AI security for software engineering, software text analytics and bug and vulnerability analysis. He received his Ph.D. in 2012 from Singapore Management University.



Chenhan Xu has joined the department as an Assistant Professor. His research interests are in mobile computing / sensing system and machine learning for human-computer interaction and mobile health / cyber-physical systems security. He received his Ph.D. in 2023 from the University at Buffalo, the State University of New York.



Computer Science Research

Our key research areas are in:

- **Artificial Intelligence and Theory** including Intelligent Agents, Machine Learning, Knowledge Representation, Planning, Natural Language Processing, Computational Economics and Management, Algorithms, Theory of Computation
- **Computational Applications and Analytics** including Data Intensive Computing, Scientific Computing, Bioinformatics, Data/Text Mining, Information Visualization, Healthcare Information Technology, Analytics Clouds, Data Science
- **Games, Interaction, and Education Informatics** including Games, Human-Computer Interaction, Graphics, Intelligent Tutoring, Undergraduate Education in Computing
- **Cybersecurity** including Information Assurance, Privacy, Policies, Regularity Compliance, Networking and Performance Evaluation, Web Security, Mobile Security, Crypto, Internet of Things
- **Networks** including Software and Network Systems Security, Performance Analysis, Wireless and Mobile Networking, Network Analytics, Internet of Things, Internet Architecture and Protocols
- **Software Engineering** including Requirements, Formal Methods, Policies, Reliability Engineering, Process and Methods, Programming Languages, Testing and Verification
- **Systems** including Computer Architectures and Operating Systems, Databases, Embedded and Real-Time Systems, Parallel and Distributed Systems, High Performance Computing, Cloud Computing

NC State University is a Tier 1 research institute, and with 13 research centers and more than 35 research labs and groups, research is at the very core of the NC State Computer Science Department's mission.

NC STATE Engineering

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