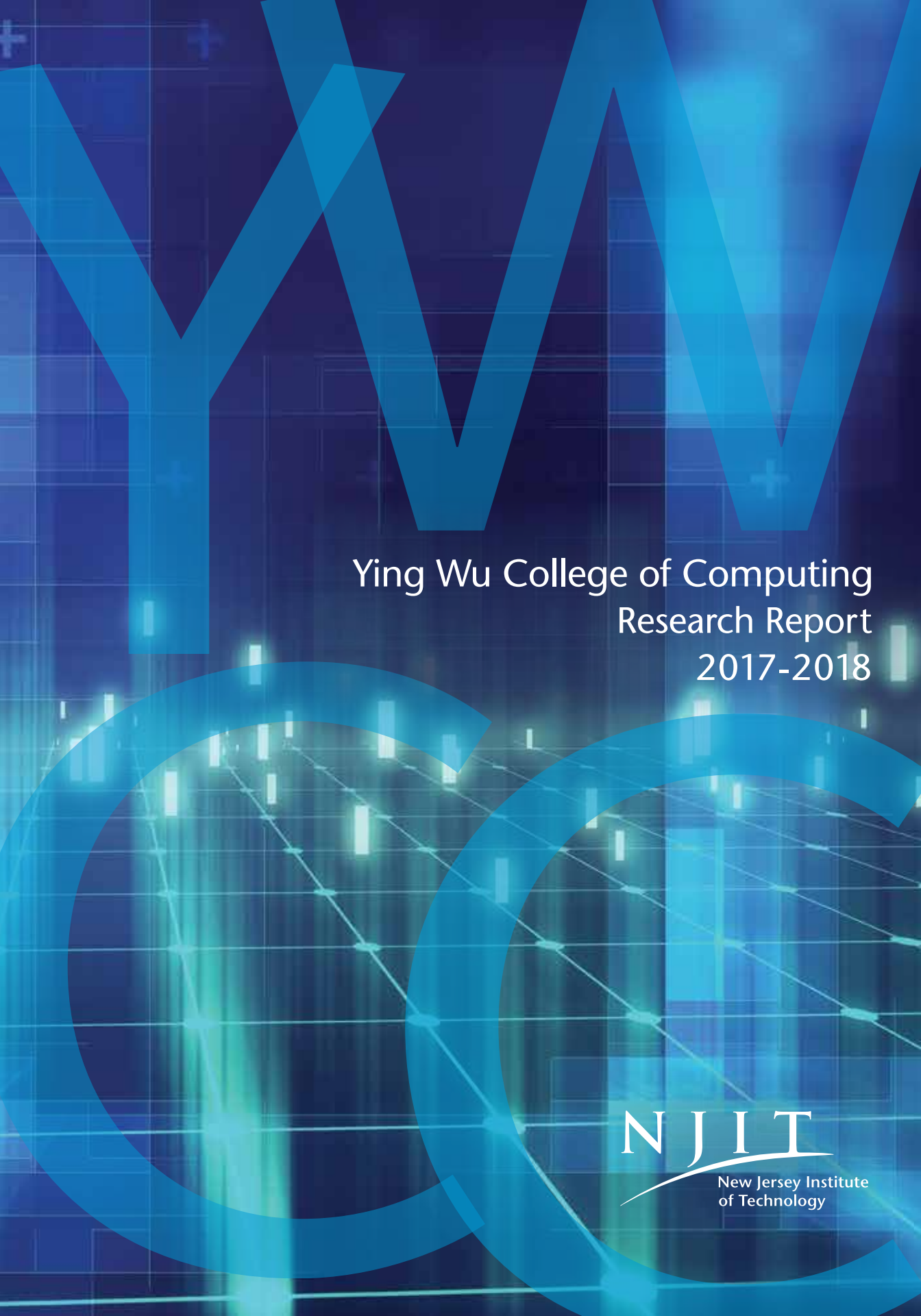

Ying Wu College of Computing Research Report 2017-2018

NJIT
New Jersey Institute of Technology

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Dean
Craig Gotsman

Associate Dean for Research
James Geller

Editor
Shydale James

Art Director/Designer
Diane Cuddy

Photo Editor
Deric Raymond

Copy Editor
Julie Jacobs

Production Manager
Babette Hoyle

Dean's Message

Why computing research?

Because computing technology has completely shaped the last half-century of our lives, yet its biggest potential still lies ahead.

Computing has eliminated boundaries of space and time and has created a common store of human knowledge that dwarfs anything that previously existed. It has changed our way of seeing and exploring nature, and created a new paradigm through which all scientific disciplines query the world.

Computing has also dramatically increased productivity in business, industry and management by creating cyberspace: The ubiquitous collection of networks and computers that functions as the nervous system of modern society. Cyberspace provides infrastructure for telecommunication, energy grids, transportation, business, commerce and banking. Increasingly, cyberspace is the medium in which we work, socialize, learn, entertain, shop and imagine.

NJIT established Ying Wu College of Computing in 2001, reflecting its desire to make computing a centerpiece of its vision for the 21st century. As the only college of its kind in New Jersey, and one of the few in the U.S., we're completely focused on computing education and collaborative research, ranging from networking and computer security to big data analytics, biomedical informatics, gaming and virtual reality.

The following pages describe the creative work of our talented researchers, who employ a range of cutting-edge methodologies to advance computing science and technology on a daily basis. Their efforts have garnered financial support from the federal government, corporations and nonprofits — and the results have been published in prestigious journals and presented in top conference venues worldwide.

Although told in brief, each project represents countless hours of research and carries on the tradition of innovation to which we've become accustomed at Ying Wu College of Computing. The work of our scholars features significant contributions from their students and colleagues, culminating in efficient algorithms, useful and usable computing systems and, above all, a better understanding of how computing can be used to solve problems, enrich lives and advance mankind.

This report would not have been possible without the creative writing of Shydale James of NJIT's Office of Strategic Communications, assisted by our Associate Dean for Research — Dr. James Geller.

I wish you pleasant and informative reading.

Craig Gotsman
Dean, Ying Wu College of Computing

Big Data & Analytics

MANAGING SOLAR FLARE DATA

Solar flares are the most prominent manifestation of the sun's magnetic activity. They emit radiation that could potentially damage power systems, interfere with civilian and military radio frequencies and disrupt spacecraft operations. Dr. Vincent Oria is working on a project that aims to integrate and enrich solar data captured by various solar flare observing instruments around the world.

PRESERVING SENSITIVE HEALTH CARE INFORMATION

Networks that share electronic health care records containing a patient's personal and clinical records promise improved continuity of care and better health outcomes. But at the same time, these networks put highly sensitive patient information at risk and expose health care providers to legal jeopardy. Dr. Hai Phan is using machine learning techniques to create DeepPrivate, a system that protects personal medical information against cyberattacks.

TAPPING INTO DATA VISUALIZATION

The sheer volume of big data makes it difficult to validate complex models or detect new patterns using traditional data analysis methods. Presenting data in pictorial and graphical formats is a vital tool in the age of big data. Dr. Chase Wu's work helps users of scientific and business applications make sense of data for fast and accurate decision-making.

UNCOVERING LOW-LEVEL, HAZARDOUS RADIATION

Radioactive substances and biological agents present a serious threat to public health and safety, particularly in densely populated areas. Funded by the Domestic Nuclear Detection Office of the Department of Homeland Security, Dr. Chase Wu's research is developing reliable tools for detecting and localizing radioactive materials to protect the populace and reduce the risk of radiological dispersal devices, such as "dirty bombs."

IMPROVING URBAN MOBILITY

From atmospheric pollution and traffic congestion to longer commutes and parking constraints, we face a dizzying array of urban transport problems on a daily basis. Dr. Hai Phan analyzes, explores and visualizes big traffic data from predicting driver behavior to modeling and forecasting traffic. The result is a set of powerful insights into how smart city technologies can address the transportation issues plaguing urban regions.

REVOLUTIONIZING THE PROCESSING OF BIG DATA SETS

Scientific applications generate terabytes of data, which must be stored, managed, processed and analyzed. To tame the explosion of information overwhelming scientific computing infrastructures, Dr. Chase Wu is developing practical computing and networking toolkits for complex workflows in high-performance environments. The optimization of big data workflows will reduce the computing cycle time of the research process and allow scientists to concentrate on their scientific goals.

REDUCING ENERGY CONSUMPTION IN BIG DATA

The transfer of big data across high-performance networks consumes a significant amount of energy on a daily basis. Employing two widely adopted power models — power-down and speed scaling — Dr. Chase Wu is working on an approach that will enable network providers to reduce operational costs and also reduce their carbon dioxide emissions to protect the environment.

PROMOTING EFFECTIVE GROUP COLLABORATION

Drawing on research in social psychology, organization theory and cyber-human systems, Dr. Senjuti Basu Roy addresses the challenges of next-generation collaborative crowdsourcing applications. This multidisciplinary research is developing novel mathematical models and algorithms that will facilitate the creation of working groups, allowing them to make collaborative decisions while pursuing multiple objectives.

Cybersecurity

DEFENDING SOFTWARE SUPPLY CHAINS AGAINST HACKERS

Dr. Reza Curtmola spearheaded the creation of the YWCC MS degree program in cybersecurity. He is developing in-toto, a system that promises to safeguard software for developers and end users. By raising the bar for attackers, in-toto will provide organizations with insight into the software development and distribution chain, and determine if proper software development practices have been followed.

DEVISING APPLIED SOFTWARE SECURITY TECHNIQUES

As director of the NJIT Cybersecurity Research Center, Dr. Kurt Rohloff leads a team of experts developing encrypted computing technologies to address our current inability to protect software from being reverse engineered and re-used without permission. Bridging the gap between theory and practice, the PALISADE and OPERA projects are part of a DARPA-funded R&D effort to produce effective program obfuscation techniques that will better protect our nation's investments in innovative software.

BOLSTERING THE INTEGRITY OF REMOTELY-STORED DATA

Funded by a National Science Foundation CAREER grant, Dr. Reza Curtmola is establishing a practical remote data checking (RDC) framework to provide long-term integrity and reliability for remotely stored data. Additionally, the project seeks to develop new functionality for RDC that overcomes limitations of early protocols and improves the usability and deployment of RDC on existing cloud storage infrastructures. If successful, the mechanism will minimize the combined security costs of all data management phases, increase the transparency of cloud storage platforms and improve the security dimension of storage outsourcing, enabling wider adoption of cloud storage technologies and giving owners better control over their data.

SAFEGUARDING CLASSIFIED INFORMATION

The leaking of classified information by Edward Snowden revealed the existence of previously unknown large-scale surveillance. Dr. Qiang Tang is designing new cryptographic techniques that will protect classified communication and information in the presence of malicious software and hardware.

DEBUGGING COMPUTER PROGRAMS

Dr. Ali Mili explores the concept of relative correctness, using a static analysis approach to test and debug computer programs. His work also investigates the introduction and analysis of similar properties for cybersecurity practices.

PROTECTING ARMY NETWORKS AND SECURING SMARTPHONES

Dr. Iulian Neamtiu is part of the 10-year Cybersecurity Collaborative Research Alliance, a joint effort between the Army Research Laboratory, Applied Communication Services and six universities. With a focus on Moving Target Defense, deception, and assessing user and software risk, Neamtiu aims to advance the foundations of cybersecurity in the context of military networks. Neamtiu's group has also developed a variety of techniques for improving Android's reliability and security. Released as open-source tools, his innovative approach to static and dynamic analyses helps users, developers and researchers reproduce and debug executions, find lost data and assess app risk.

COMBATING DATA LEAKS

RAMPARTS, PARAPET and REVET are a trio of projects led by Dr. Kurt Rohloff that develop and apply software engineering tools for a new family of encryption technologies. These projects will result in a general open-source software library allowing organizations to outsource computation to cloud computing environments, without risking privacy and leaking sensitive information to potential adversaries.

Networking, Cloud Computing & Mobile Computing

EASING TRAFFIC CONGESTION AND COMMUTER CLOG

Traffic jams, particularly caused by inefficient intersection traffic control, reportedly cost U.S. drivers an average of $1,200 annually in wasted fuel and time and are a leading cause of environmental deterioration. Drs. Guiling Wang and Joyoung Lee have partnered with University of Houston's Dr. Zhu Han to create a cutting-edge, self-cognizant urban traffic signal control system based on machine learning. Employing innovative mobile sensing technologies, the team is fashioning a responsive signal control system that adapts to changing traffic conditions. Wang and Lee are also working with colleagues at Rutgers University on a project that allows vehicle navigation decisions to be made on the spot, using a real-time urban route guidance system.

ENABLING HIGH-PERFORMANCE CLOUD COMPUTING

The persistent uploading, downloading and processing of images, videos and files to and from the cloud can lead to inefficiency and delayed response times due to irregular computing demands. Dr. Andrew Sohn's research will help cloud servers, such as Amazon's Elastic Compute Cloud and Microsoft Azure, meet the power and computing requirements of mobile as well as enterprise cloud applications. Dr. Xiaoning Ding also leads two projects that seek to increase data processing speeds in the cloud and on other virtualized platforms in modern computer infrastructures.

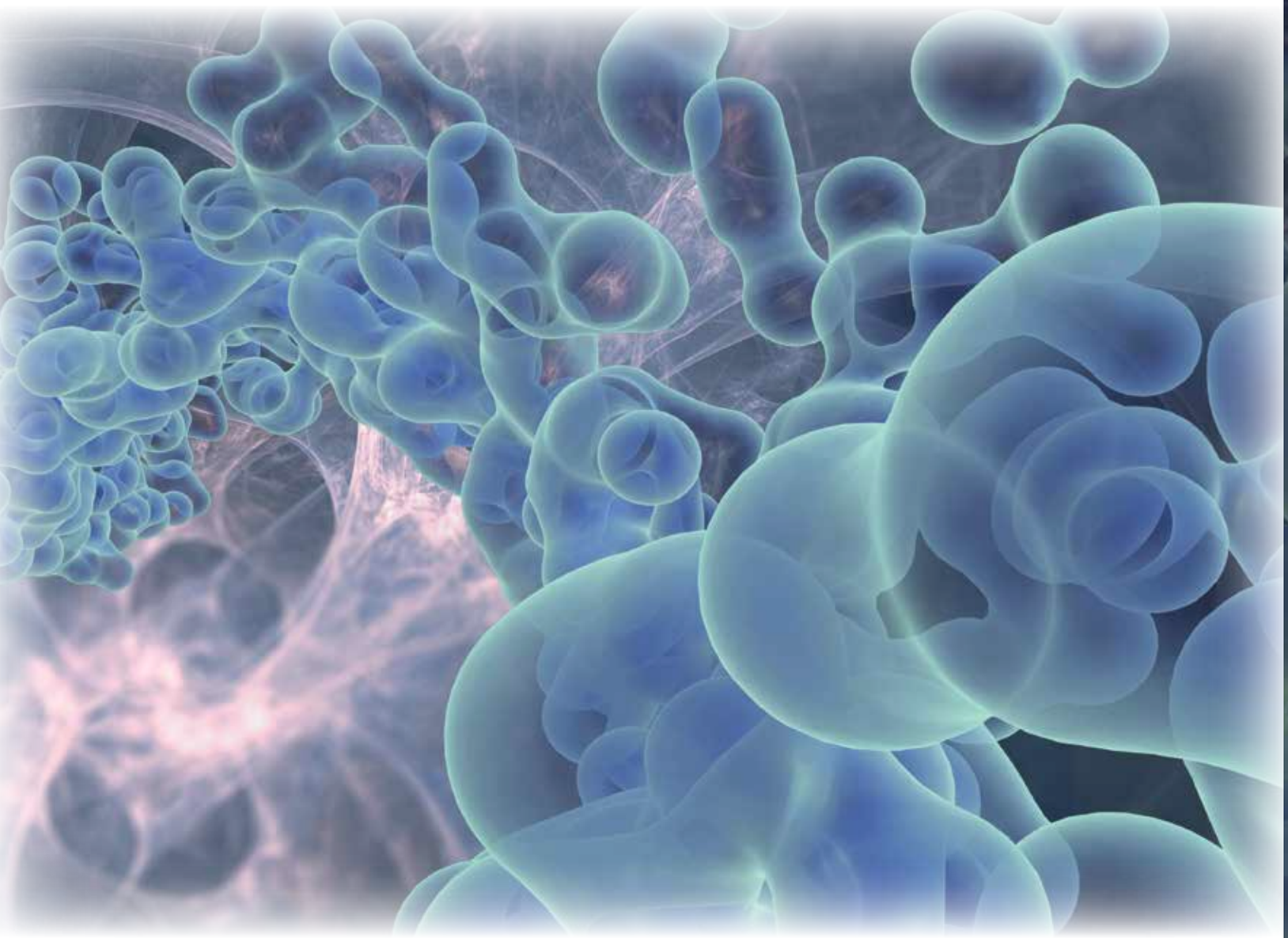
PROPELLING MOBILE-DISTRIBUTED CLOUD COMPUTING

Mobile-distributed computing enables direct collaboration among smartphone and tablet users. Yet, mobile-distributed applications are difficult to deploy due to the limited energy and bandwidth resources of mobile devices. Drs. Cristian Borcea, Narain Gehani, Xiaoning Ding and Reza Curtmola are investigating ways cloud computing can support mobile-distributed computing. Their research will explore what cloud protocols and architecture optimizations are necessary to support these applications, and determine what privacy mechanisms are needed to protect users while ensuring effective usability and development.

USING GAMIFICATION TO COLLECT DATA

Measuring and harvesting large datasets from the field using sensing devices known as mobile crowdsensing can identify a broad spectrum of environmental, infrastructure and social needs. However, developing a method to incentivize people to collect and share sensor data in unpopular regions remains a major challenge. Drs. Cristian Borcea and Reza Curtmola designed, built and evaluated two Android-compatible crowdsensing systems for NJIT students: a mobile game that uses an incentive-centered design to convince participants to cover all the regions of a target area, and a micropayment structure that allows users to pick their own sensing tasks. The results suggest that gaming is a cost-effective solution for uniform area coverage, while micropayments work well for sensing tasks with tight time constraints or long-term tasks for personal analytics.

Biomedical Informatics



MINING SOCIAL MEDIA TO COMBAT CANCER

Dr. Songhua Xu leverages the power of online patient communities and user-generated content on social networking sites like Facebook to understand complex migration patterns and their effect on environmental cancer risk. His work, funded by the National Institutes of Health, provides a complementary approach to the standard paradigm of observational medical research.

UNDERSTANDING STRUCTURED DATA MINING

NetExplorer, a robust suite of algorithms, tools and web servers created by Dr. Jason Wang, will tap into biological and social networks for structured data mining. The software also has the potential to advance disease treatment and facilitate the prediction of consumer influence.

CONVERTING DATA INTO ACTIONABLE INTELLIGENCE

Enterprises and government entities continue to glean crucial insight from Dr. Zhi Wei's data research. His work assists in the conversion and integration of data science and advanced analytics to drive innovation and development in many sectors, including finance, biology, cancer treatment and health care.

ACCELERATING MACHINE LEARNING FOR MEDICINE

Bioinformatics Program Director Dr. Usman Roshan is developing new machine learning algorithms for graphic processing units that enable the comparison of large biological sequences, and the prediction of cancer and disease risk from genomic data. This has broad applications leading to a better understanding of biology and accurate medical diagnoses.

OVERCOMING OBSTACLES IN DATA CLASSIFICATION

From federal tax records and social security numbers to passwords and protected health information, the grouping and protection of diverse confidential data is difficult to implement and prone to overfitting. Through the observation of real data, Dr. Usman Roshan is establishing new features for nonlinear classification that are easier to implement, run faster and regulate overfitting.

COMPREHENDING DATA IN MEDICAL TERMINOLOGIES

Drs. Yehoshua Perl and James Geller, who co-direct the Structural Analysis of Biomedical Ontologies Center — supported by the National Institutes of Health — work on family-based quality assurance of biomedical ontologies. The software created to streamline the medical terminologies makes it easier for researchers and medical professionals worldwide to access, share and grow repositories of biomedical information. Drs. Perl and Geller are also developing methods to interpret large collections of formal medical knowledge stored on computers, which will aid in the prediction of dangerous drug-drug interactions.

Human-Centered Computing

ADVANCING COMPUTER SCIENCE EDUCATION

Dr. Michael J. Lee, with support from the National Science Foundation, is exploring unique approaches to teaching computer programming. His approach provides customized content to the learner based on historical data and analysis of user engagement. He will test his methods on and use data from Gidget (helpgidget.org), an online game he created to teach programming concepts.

EXPLORING THE LINK BETWEEN SOCIAL MEDIA AND WELL-BEING

Dr. Donghee Yvette Wohn, director of the Social Interaction Lab, is exploring the connection between psychological health and technology usage — with an emphasis on how social media plays a role in facilitating social support. Wohn has already developed social-and-media-related applications for first-year college students and women in STEM fields. Dr. Wohn is also harnessing the power of behavior change to develop and test applications that self-regulate everything from study habits and sedentary behavior to glucose levels. Her work underscores the psychological impacts of modern-day social interactions and maximizes the effectiveness of technology to positively influence behaviors that nourish mental health and well-being.

EDUCATING VIA VIRTUAL REALITY

Eric Nersesian, director of the Virtual Reality (VR) Lab, is working on the use of VR simulations in the study of architectural history, binaural audio and theatrical performance. Nersesian and his collaborators are building an educational VR robotics and programming app for the John E. Dwyer Technology Academy in Elizabeth, N.J., and a nature-focused app with guidance from the Turtle Back Zoo. Nersesian is also working with Picatinny Arsenal's ARDEC for VR training research and with NJIT's Biomedical Vision Lab to use VR techniques in vision therapy.

REDEFINING STUDENT ENGAGEMENT

Participatory learning deepens learning through active involvement in the entire lifecycle of assignments, exams and other course activities — including peer grading and self-assessment. Dr. Michael Bieber is working on a web application that functions as an educational dashboard, integrates commenting and mentoring capabilities, and automatically allocates tasks to students.

RESEARCHING WEARABLE TECHNOLOGY IN CLASSROOMS

Classroom dynamics continue to evolve as more students use their personal wearable technology — smartglasses, watches, wristbands and contact lenses — in ways that are undetectable by instructors and peers. Research conducted by Drs. Michael Bieber and Starr Roxanne Hiltz is the first to systematically investigate and determine how best to design learning, teaching and assessment when personal wearable technology is used undetectably in classroom settings.

Information Science

AUTOMATING MEANINGFUL LEARNING

Informatics Department Chair Dr. Brook Wu is working on a project that will improve students' understanding of course content. As a pedagogical strategy, Write-and-Learn provides a framework that generates automated formative feedback by comparing the concepts introduced in teaching materials and students' writing assignments. Her work will evaluate the effectiveness of automated formative feedback and explore how such feedback can scaffold and promote meaningful learning.

Theory & Operations Research

REDUCING ERROR IN RISK ASSESSMENT

Dr. Marvin Nakayama is working to reduce errors in Monte Carlo simulation, which is a computational technique that is used to measure risk in quantitative analysis and decision-making. Having the ability to estimate the probability of cost overruns in large projects or assess the likelihood of a hurricane severely damaging critical infrastructure benefits professionals in such widely disparate fields as civil and mechanical engineering, finance and project management.

STUDYING NEW PARALLEL COMPUTING PRACTICES

Dr. Alex Gerbessiotis explores the use of parallel computing techniques to speed up processing and increase memory performance. He is also working on parallel algorithm design, analysis and implementation to make multicore processors accessible to software developers solving problems in financial engineering and big data.

EXPLORING GLOBAL OPTIMIZATION

To solve the optimization problems that pervade engineering, science and commerce, Dr. James Calvin is developing methods that will help companies bring their costs to the absolute minimum. The application of his work could potentially help engineers design fuel-efficient aircraft, computer scientists decrease the error rate of classification algorithms and portfolio managers choose investments to maximize expected returns.

SUPPORTING GLOBAL SUPPLY CHAINS

Manufacturers are tasked with making crucial logistical decisions that lead to cost-effective ways to produce and distribute items. Dr. Joseph Leung develops efficient computational methods for the economical planning, scheduling and transportation of commodities and merchandise in global supply chains.

Computer Vision

MAKING INTELLIGENT TRANSPORTATION SYSTEMS SMARTER

Backed by the New Jersey Department of Transportation (NJDOT), which operates over 400 traffic video cameras, Dr. Chengjun Liu is developing video-processing software that will prevent congestion and reduce economic loss by automatically detecting traffic incidents. Liu is also spearheading the enhancement and implementation of an automated video analysis prototype at NJDOT's Arterial Management Center to process the live video feed from traffic cameras for vehicle volume analysis in challenging environments and weather conditions.

CREATING OPTIMAL WATERMARKS

Dr. Frank Shih is working on image watermarking techniques that hide secret data for copyright protection, image authentication, data privacy and broadcast monitoring. He aims to develop the highest capacity and lowest image distortion by using an intelligent scheme for automated watermark embedding.

ELIMINATING THE BLIND SPOT

Heterogeneous car video recorders can capture scene information with different modalities, angles, resolutions and lens sensors. Dr. Frank Shih is working on a novel approach to stitch together heterogeneous images, allowing a driver to view an angle without blind spots. He is also developing feature detection and matching tools that will integrate all the images from multimodal sensors and stitch them into a wide-angle image.

Databases & Semantic Web

DETECTING PATTERNS IN GRAPH DATA

Dr. Dimitri Theodoratos is designing holistic algorithms to extract patterns from large data trees and graphs, which is central for analyzing data and the first step for other data mining processes. The application of his research can detect patterns of disease occurrences among patients and their ancestors.

STRENGTHENING KEYWORD SEARCH FUNCTIONS

Keyword search is the most popular method used to explore the internet. But often, searching by keyword yields too few or too many results. Dr. Dimitri Theodoratos is designing algorithms that can efficiently compute and extract patterns on large datasets so that users obtain relevant and properly ranked search results from keyword queries.

Meet the Researchers

Department of Computer Science

Cristian Borcea
Professor
Mobile cloud computing and sensing; ad hoc and vehicular networks; cloud and distributed systems
borcea@njit.edu
973-596-2866

James Calvin
Professor
Global optimization; algorithm analysis
james.m.calvin@njit.edu
973-596-3378

Reza Curtmola
Associate Professor
Applied cryptography; mobile computing; crowdsensing; wireless networks
crix@njit.edu
973-596-5776

Xiaoning Ding
Assistant Professor
Computer architecture; operating systems; parallel and distributed systems
xiaoning.ding@njit.edu
973-596-3390

Narain Gehani
Professor
Web technologies; software systems
narain.gehani@njit.edu
973-596-2318

James Geller
Professor
Health computing; biomedical informatics
james.geller@njit.edu
973-596-3383

Craig Gotsman
Distinguished Professor
Computer graphics; geometry processing; visualization
craig.gotsman@njit.edu
973-596-5488

Joseph Leung
Distinguished Professor
Scheduling theory; real-time systems; operating systems; computational complexity
joseph.y.leung@njit.edu
973-596-3387

Chengjun Liu
Professor
Pattern recognition; machine learning; computer vision; image and video processing; biometrics
chengjun.liu@njit.edu
973-596-5280

Ali Mili
Professor
Technical, organizational and managerial software engineering
ali.mili@njit.edu
973-596-5215

Marvin K. Nakayama
Professor
Risk analysis; probabilistic safety assessments; fault-tolerant systems; applied probability; statistics
marvin@njit.edu
973-596-3398

Iulian Neamtiu
Associate Professor
Programming language; software engineering; smartphone security
iulian.neamtiu@njit.edu
973-596-3340

Vincent Oria
Professor
Advanced database systems
vincent.oria@njit.edu
973-596-5767

Yehoshua Perl
Professor
Quality assurance of biomedical terminologies and ontologies
yehoshua.perl@njit.edu
973-596-3392

Kurt Rohloff
Associate Professor
Encrypted computing; homomorphic encryption; cryptography; cybersecurity; secure communication protocols
kurt.rohloff@njit.edu
973-596-3382

Usman Roshan
Associate Professor
Sequence alignment; disease risk prediction; high-performance computing; GPU algorithms
usman.w.roshan@njit.edu
973-596-2872

Senjuti Basu Roy
Assistant Professor
Health informatics, analytics and optimization in crowdsourcing; graph mining; social network analysis
senjuti.basuroy@njit.edu
973-596-3662

Frank Shih
Professor
Digital watermarking and forensics; image processing; information security; pattern recognition
frank.y.shih@njit.edu
973-596-5654

Andrew Sohn
Associate Professor
Adaptive computing infrastructure; virtual machines
andrew.sohn@njit.edu
973-596-2315

Qiang Tang
Assistant Professor
Copyright protection; post-Snowden cryptography; blockchain technology; privacy-preserving data processing
qiang.tang@njit.edu
973-596-2656

Dimitri Theodoratos
Associate Professor
Query processing; data warehousing and integration; semantic web
dimitri.theodoratos@njit.edu
973-596-5213

Guiling Wang
Professor
Mobile computing; network and system security; intelligent on-road transportation; wireless sensor networks
guiling.wang@njit.edu
973-596-5211

Jason Wang
Professor
Data mining; bioinformatics; machine learning; computational biology; software development; cyberinfrastructure
jason.t.wang@njit.edu
973-596-3396

Zhi Wei
Associate Professor
Statistical modeling; machine learning; big data analytics
zhi.wei@njit.edu
973-642-4497

Chase Wu
Associate Professor
Big data analytics; green computing and networking; cybersecurity; parallel and distributed computing
chase.q.wu@njit.edu
973-642-4579

Department of Informatics

Michael Bieber
Professor
Learning sciences; lightweight systems integration; automatic link and meta information generation
michael.p.bieber@njit.edu
973-596-2681

Michael Halper
Professor
Data modeling; medical informatics
michael.halper@njit.edu
973-596-2681

Starr Roxanne Hiltz
Distinguished Professor Emerita
Virtual teams and online communities; online learning; emergency response information systems; social media
roxanne.hiltz@njit.edu
973-596-3388

Michael J. Lee
Assistant Professor
Computing education research; human-computer interaction
michael.j.lee@njit.edu
973-596-5897

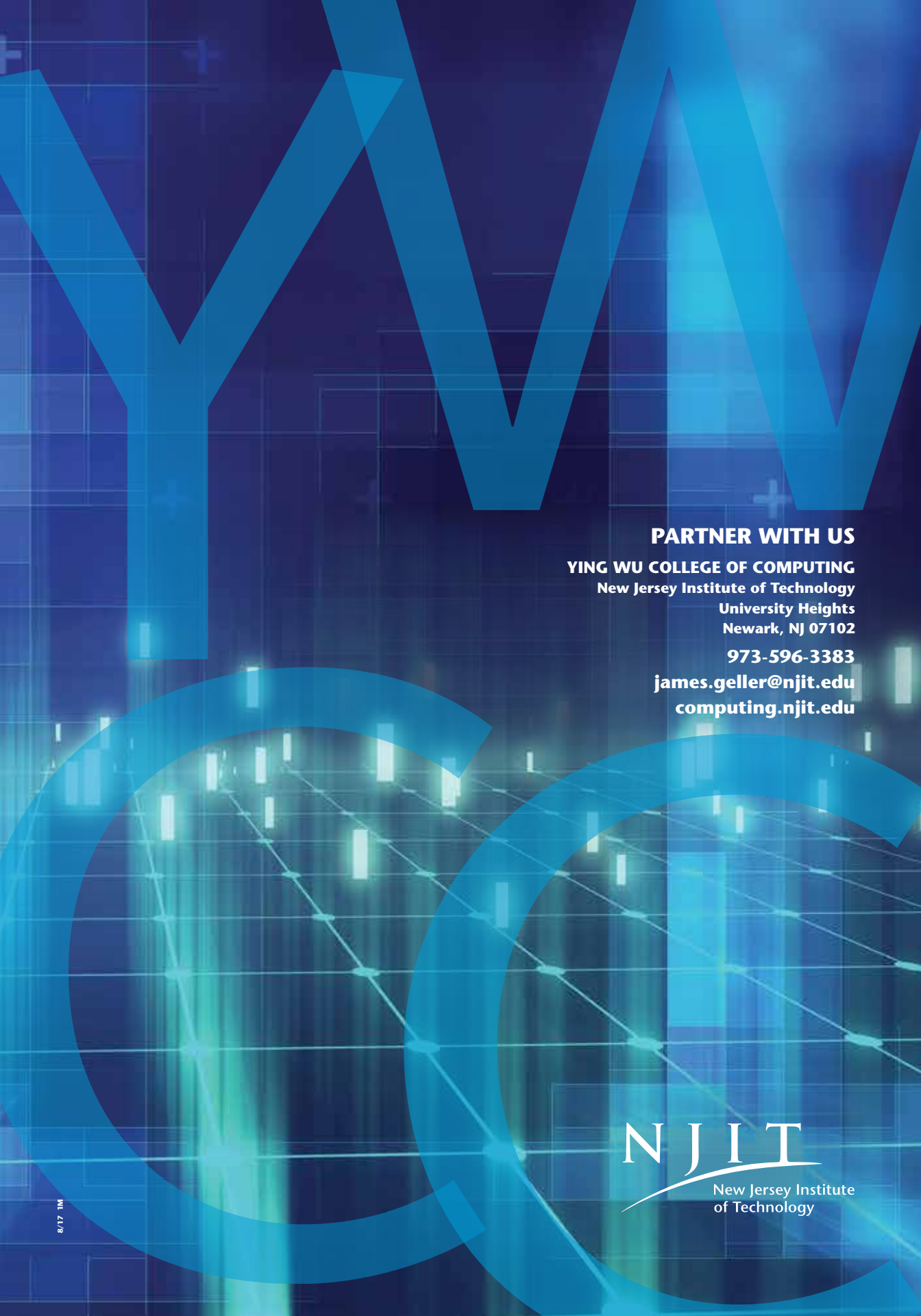
Eric Nersesian
University Lecturer
Game development; interactive computer graphics; virtual reality
eric.nersesian@njit.edu
973-873-5710

Hai Phan
Assistant Professor
Smart city technologies; big traffic data; traffic modeling and forecasting
hai.phan@njit.edu
973-596-3104

D. Yvette Wohn
Assistant Professor
Social systems; social mobile application development
donghee.y.wohn@njit.edu
973-596-5291

Brook Wu
Associate Professor
Text mining; user search behavior; information retrieval
yi-fang.wu@njit.edu
973-596-5285

Songhua Xu
Assistant Professor
Web search and data mining; artificial intelligence; biomedical applications
songhua.xu@njit.edu
973-596-5815



PARTNER WITH US

YING WU COLLEGE OF COMPUTING
New Jersey Institute of Technology
University Heights
Newark, NJ 07102

973-596-3383
james.geller@njit.edu
computing.njit.edu

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New Jersey Institute
of Technology

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