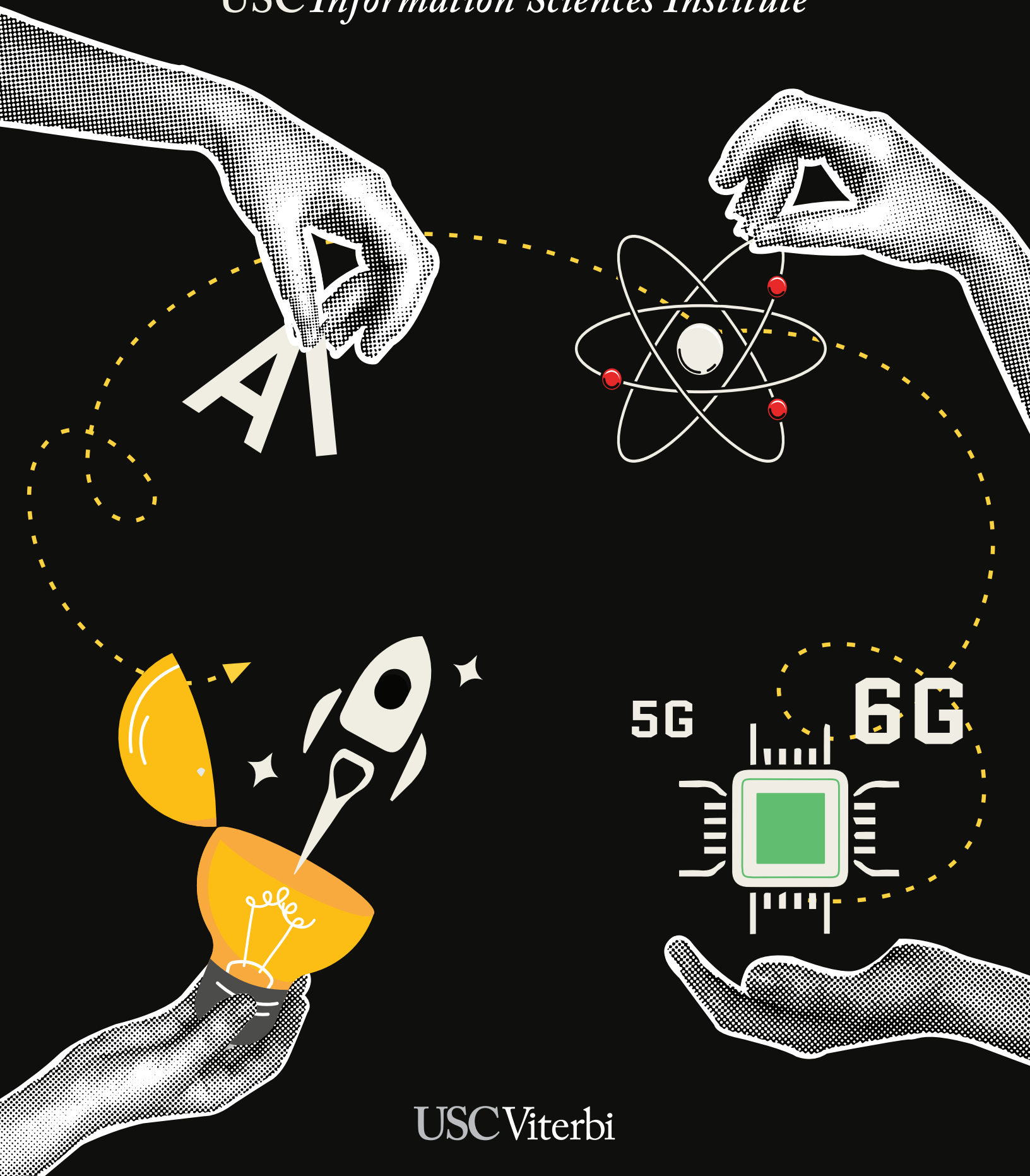
2024 YEAR *in* REVIEW

USC *Information Sciences Institute*



USC Viterbi


NATURAL
CYBER
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MICROELECTRONICS

ILLUSTRATION BY **SHANTELL MARTIN**

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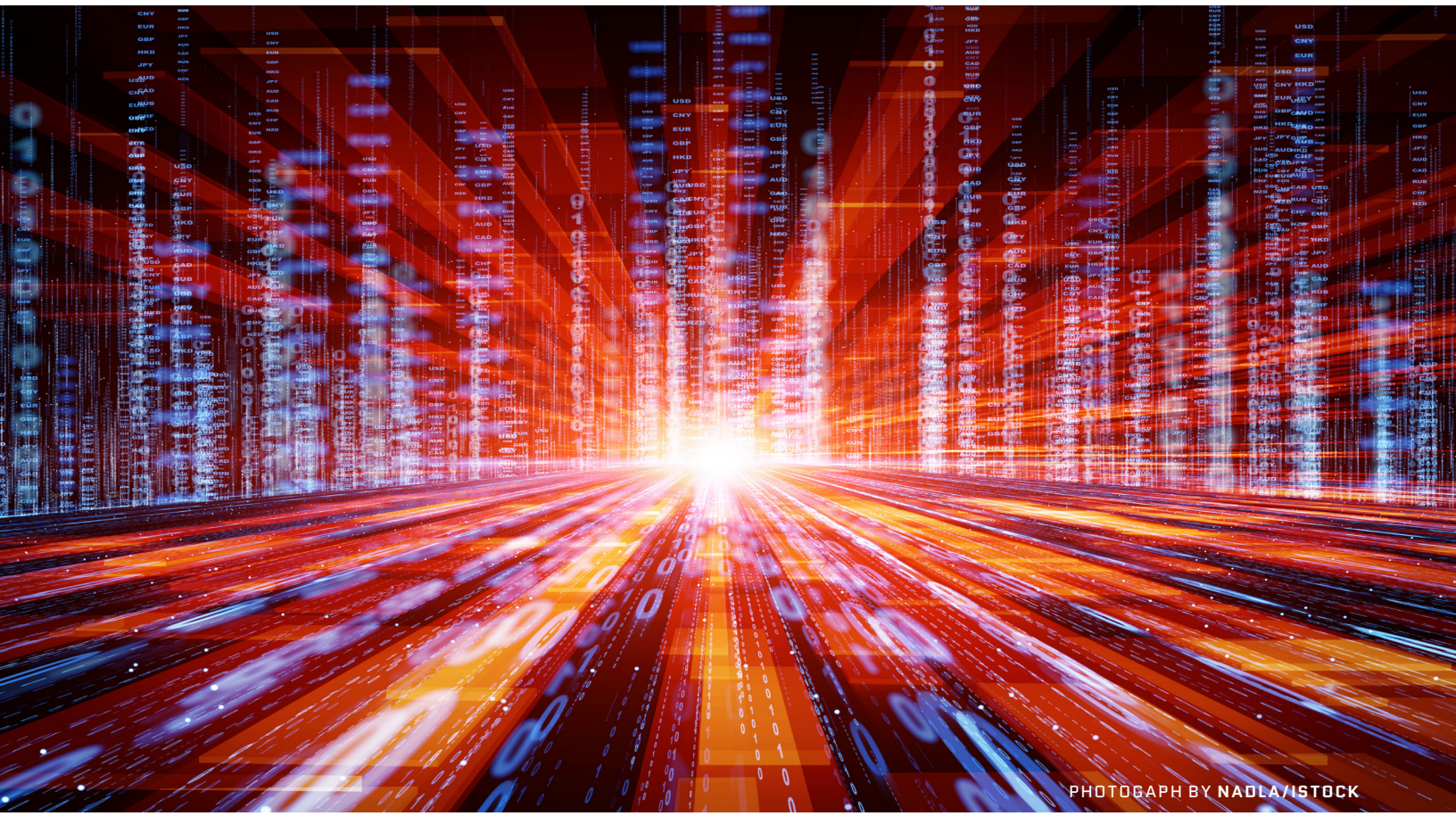

PHOTOGRAPH BY NADLA/ISTOCK

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New Gen Ph.D.s

Seven Ph.D. students who graduated in 2024 recall their years at the institute, and how ISI has impacted the way they approach research

"At ISI, innovation is how we think"

CRAIG KNOBLOCK
ISI KESTON EXECUTIVE DIRECTOR

At ISI, innovation isn't just about our discoveries, it's about the way we approach the challenges of tomorrow. This year, we've refined how we frame our work, emphasizing the big ideas driving our research.

By highlighting key research themes — as seen on the cover — we're emphasizing collaborations that define ISI and amplify the impact of our work. AI for health, microelectronics, space, 5G and 6G networking, integrated quantum systems, responsible AI — these are areas of research that cross divisions and disciplines. They not only illustrate where ISI is headed but also highlight our commitment to tackling the pressing challenges shaping the future of science, technology, and society.

ISI's strength has always been its ability to bridge disciplines, bringing together researchers with diverse expertise to solve complex problems. These research themes reflect our vision for a more connected and secure future, ensuring that the work we do continues to resonate with collaborators, partners, and the broader public.

Beyond the lab, we are finding new ways to connect technology and culture. This year, we were thrilled to welcome world-renowned artist Shantell Martin as ISI's first artist-in-residence, underscoring the role of creativity in driving innovation. And I'm also pleased to share that our documentary, *Cloudwalkers: ISI and the Inventors of the Future*, is now streaming on Amazon Prime, inviting a global audience to learn about ISI's legacy and vision.

As we look back on this year and prepare for the next, one thing is constant: ISI's strength lies in its ability to evolve. By fostering creative partnerships, bringing together diverse expertise, and staying focused on the big questions, we continue to shape the future of technology.

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2024 YEAR IN REVIEW

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Three locations, one *mission*

ISI's mission is to advance society through pioneering research and technological innovation. We cultivate an intellectually vibrant environment where researchers are empowered to imagine bold solutions to problems and develop into world-class leaders. Guided by integrity and a commitment to excellence, we create unprecedented capabilities that harness information to transform lives. ISI is a place where people can be inspired to realize their potential, an inclusive community where everyone can thrive and feel that they belong.

"ISI researchers are visionary scientists who relentlessly push the envelope of computational capabilities, venturing into uncharted territories of application with a firm belief that creativity is the cornerstone of truly revolutionary scientific achievements," said Ishwar K. Puri, USC senior vice president of research and innovation.

The institute's work is characterized by a focus on real-world impact, and our staff gets to work in world-class facilities distributed across three sites. Our headquarters are in a coastal location in Marina del Rey, California, in a vertical campus across nine floors. Two additional sites are Arlington VA, and Boston MA, and personnel are working remotely in several other locations.

ISI's uniqueness lies in being a very large, university-affiliated research lab, working with a hundred Ph.D. students and junior to well-established researchers and engineers. This allows ISI to manage very large projects with research systems integration and deliverables.

Initially funded by ARPA (now DARPA) to help build the Internet, ISI now focuses on the many challenges facing society today. Our dedicated researchers' mission is to transform lives. And it is our staff, faculty and students that make this possible. ■

MARINA DEL REY, CA

ARLINGTON, VA

BOSTON, MA

ISI at
LA Tech Week

ISI took center stage during LA Tech Week 2024, held October 14-18, 2024, hosting a series of events that highlighted cutting-edge technology and fostered connections within the tech community.

Set in the heart of Silicon Beach, ISI opened its doors to entrepreneurs, researchers, and innovators, offering a platform for collaboration, inspiration, and deep dives into the future of technology. With a lineup of AI panels, lab tours, a film screening, and rooftop mixer, the week proved to be an exciting celebration of innovation and technology.

Craig Knoblock, executive director of ISI, expressed his enthusiasm: "We're thrilled by the incredible turnout and engagement we saw during LA Tech Week. It was a unique opportunity to showcase the groundbreaking work we're doing and connect with so many talented individuals who share our passion for technology."

TWO AI PANELS

The week kicked off with the AI Titans panel, where over 60 attendees heard from leading figures in AI. The panel featured Yu-Han Chang, co-founder of Second Spectrum, and Kevin Knight, Daniel Marcu, and Bryce Benjamin, co-founders and original CEO, respectively, of Language Weaver. They shared firsthand experiences about transforming research into successful commercial ventures. The panelists discussed their journey from lab to market, offering valuable insights into identifying market opportunities, startup challenges, and the evolution of AI technology.

The second panel, AI Pioneers, was moderated by Adam Russell, director of ISI's AI division and host of the ISI podcast, AI/nsiders. It brought together some of the brightest minds in AI. Panelists included Yolanda Gil, Kristina Lerman, Jonathan May, and serial entrepreneur Karl Jacob. The discussion focused on LA's contributions to AI, the evolution of the field, and predictions for its future. Attendees were treated to an engaging debate about the next big AI breakthroughs, including how LA's unique ecosystem can contribute to global advancements in AI. Over 50 attendees left inspired by the depth and breadth of AI research emerging from ISI. If the mixer hadn't been about to start on the rooftop, the audience questions would have lasted for hours!

SCREENING of ISI'S DOCUMENTARY

ISI hosted an exclusive screening of Cloudwalkers, a documentary that uncovers the untold story of the pioneers behind the internet. Following the screening, Paul Mockapetris, the inventor of the Domain Name System (DNS) and a former ISI researcher, who narrated the film, was joined by Craig Knoblock, Kristina Lerman, and Yolanda Gil, for a Q&A session. They shared insights into the origins of the internet and the lasting impact of early innovations on today's digital landscape.

LAB TOURS OPEN TO ALL

Visitors had the chance to step inside ISI's labs for a hands-on experience of groundbreaking technology. The tours provided a closer look at advancements in quantum computing, space engineering, and cybersecurity. Guests were introduced to cutting-edge projects such as the quantum computer that operates at temperatures colder than space, as well as innovations in satellite technology and cyber defense strategies. These glimpses into the future left many excited about the potential applications of the technologies on display.

SILICON BEACH MIXER

LA Tech Week at ISI concluded with a lively rooftop mixer, attended by 150 tech enthusiasts and professionals. Co-sponsored by J.P. Morgan and Newmark, the event offered an opportunity to network with local startups while enjoying music, food, and breathtaking views of the marina. It was a perfect culmination of ISI's participation in LA Tech Week, and a celebration of the thriving innovation scene at Silicon Beach. ■

ISI hosted two seminars, a screening and a mixer for LA Tech Week.
PHOTOGRAPHS BY **ANGEL ITUA**

ISI MEDIA COV

The Los Angeles Times **AUGUST 21, 2024**

AI and deepfakes are only going to get worse this election cycle

With Emilio Ferrara, Professor of Computer Science

As the race between Trump and Democratic nominee Kamala Harris intensifies, experts are sounding the alarm about generative AI's risks. "I'm worried as we move closer to the election, this is going to explode," said Emilio Ferrara, a computer science professor at USC Viterbi School of Engineering. "It's going to get much worse than it is now." Platforms such as Facebook and X have rules against manipulated images, audio and videos, but they've struggled to enforce these policies as AI-generated content floods the internet. Faced with accusations they're censoring political speech.

NBC News **JULY 29, 2024**

More colleges are offering AI degrees

With Yolanda Gil, Director of AI Strategic Initiatives

"This is a pioneering and forward-looking interdisciplinary program," USC professor Yolanda Gil said while announcing her school's Artificial Intelligence for Business degree. "With this program, we will empower business and organizational leaders to understand the possibilities, as well as the limitations, of AI technologies and to help them better understand the people they serve, predict trends and improve decision-making processes."

Reuters **JULY 20, 2024**

Bangladesh shuts offices, imposes curfew to curb deadly job quota protests

With John Heidemann, Chief Scientist

Internet and text message services in Bangladesh have been suspended since Thursday, cutting the nation off as police cracked down on protesters who defied a ban on public gatherings. Overseas telephone calls mostly failed to connect while websites of Bangladesh-based media organisations did not update and their social media accounts remained inactive. "To take a country of nearly 170 million people off the Internet is a drastic step, one we haven't seen since the likes of the Egyptian revolution of 2011," said John Heidemann, chief scientist of the networking and cybersecurity division at USC Viterbi's Information Sciences Institute.

The New York Times **OCT 12, 2024**

Twitter banned them. What happened when they were brought back?

With Keith Burghardt, Computer Scientist

Several recent studies found that accounts posting inappropriate content and misinformation make up a tiny portion of the user base of platforms like X but produce a hugely outsized amount of damaging material. The combination of minimal content moderation and wide-reaching toxic content is not prevalent across all social media, said Keith Burghardt, a computer scientist at the University of Southern California Information Sciences Institute. To monitor conduct on the platform, Mr. Musk has largely relied on Community Notes, a program that lets certain users add fact-checking labels to posts. They vote on whether the labels are helpful, and those that are approved by the community are added by an algorithm.

Nature **OCTOBER 7, 2024**

Can AI have common sense? Finding out will be key to achieving machine intelligence

By Mayank Kejriwal, Computer Scientist

Since their public release less than two years ago, large language models (LLMs) such as those that underlie ChatGPT have unleashed exciting and provocative progress in machine intelligence. Some researchers and commentators have speculated that these tools could represent a decisive step towards machines that demonstrate 'artificial general intelligence'.

Space Force **NOVEMBER 20, 2024**

Partnering to Win: Ensuring Space Superiority

With Michael Orosz, Research Director

SSC and USC partnered up to work within real USSF programs. This team acted as a "living laboratory" to identify strategies for implementing agile development into complex defense projects, with a series of case studies focused on software for spacecrafts — or as they're commonly known, satellites. The findings (and recommendations) are influencing DoD acquisition practices, according to Mike Orosz, a research director at USC Viterbi's Information Sciences Institute (ISI), and Brian Duffy, a Senior Systems Engineer at ISI who worked on the study. The team has informed the Secretary of Defense's office on agile best practices, and their documents have been distributed throughout the Pentagon's acquisition workforce.

Fast Company **NOV 4, 2024**

USC researchers offer a glimpse inside echo chamber on social media

With Emilio Ferrara, Professor of Computer Science

Researchers at USC Viterbi's Information Sciences Institute (ISI) used machine learning to find such coordinated campaigns hidden within the millions of election-related accounts and posts on X (formerly Twitter) and Telegram. Within two separate studies conducted during May and June, the researchers documented 53 accounts on X that were coordinating their sharing activity. However, Emilio Ferrara, a professor at USC and ISI principal scientist, says the accounts included in the study were just the largest and most obviously coordinated.

The Hill **NOVEMBER 5, 2024**

New modalities of manipulation using generative AI

With Emilio Ferrara, Professor of Computer Science

"We are seeing new formats, new modalities of manipulation of some sort including … this use of generative AI [artificial intelligence], the use of these mock news websites to preach more fringe stories and, most importantly perhaps, the fact that now these campaigns span the entire media ecosystem online," said Emilio Ferrara, professor of computer science and communication at the University of Southern California. "And they are not just limited to perhaps one mainstream platform like we [saw] in 2020 or even in 2016," said Ferrara, who co-authored a study that discovered a multiplatform network amplifying "conservative narratives" and former President Trump's 2024 campaign.

Neurosciences News **APRIL 14, 2024**

Social media fuels eating disorder echo chambers

With Kristina Lerman, Principal Scientist

New research analyzes how social media group dynamics amplify behaviors harmful to mental health. A team of researchers at USC Viterbi's Information Sciences Institute (ISI) found that online social platforms create a feedback loop of eating disorder content, trapping vulnerable individuals within pro-anorexia echo chambers. The preprint has been submitted to a conference. "The social dynamic is perhaps the most harmful force on social media," Kristina Lerman, study lead author and Principal Scientist at ISI, said. "The friends you make online can actually make your mental health worse."

ERAGE

featured RESEARCH

BY YANNIS C. YORTSOS
DEAN OF THE USC VITERBI
SCHOOL OF ENGINEERING

ISI remains the jewel research institute of the Viterbi School and of USC in the fast-changing technologies of advanced computing and information sciences. Their overarching impact affects practically every area of research endeavors, across all disciplines. ISI is at the forefront of many such initiatives, aspiring to create new advances with concrete scientific, technological and innovation results. One can only look back to the key 2017 paper "Attention is all you need", with leading co-authors Ashish Vaswani and Niki Parmar, both mentored at ISI, which propelled ChatGPT and helped create the extraordinary revolution we are witnessing in LLM and AI. This legacy continues to be shaped and enhanced.

This year, our scientists continue to unlock unprecedented possibilities in computational power, enhancing our ability to solve complex problems across industries. Many are leading groundbreaking new efforts in quantum computing, sensing and communication research, also building on the pioneering establishment at ISI more than a decade ago of the first academic quantum computing center through a partnership with D-WAVE. We have also seen a significant increase in

PHOTOGRAPH BY **MAXGER/ISTOCK**

funding for our Microelectronics Commons hub, supporting advanced research and development in this crucial field. This strengthens ISI's position as a leader in the evolution of microelectronics, enabling new discoveries that will power the technologies of tomorrow.

Moreover, 2024 has been an exciting year for ISI's work on social media research, where artificial intelligence is playing a transformative role. Our researchers are developing advanced AI-driven tools that provide deeper insights into social dynamics and online behavior. This work is essential in shaping the future of ethical AI, safeguarding online interactions, and promoting more responsible and transparent digital platforms. Finally, we are poised to expand into space-related research, with new projects focused on robotics and advanced space technologies. These initiatives aim to address the growing space demand for autonomous systems and intelligent robotics.

ISI's dedication to excellence, creativity, and innovation ensures that it will remain at the cutting edge of discovery, shaping the future of computer science and advanced technology for decades to come. ■

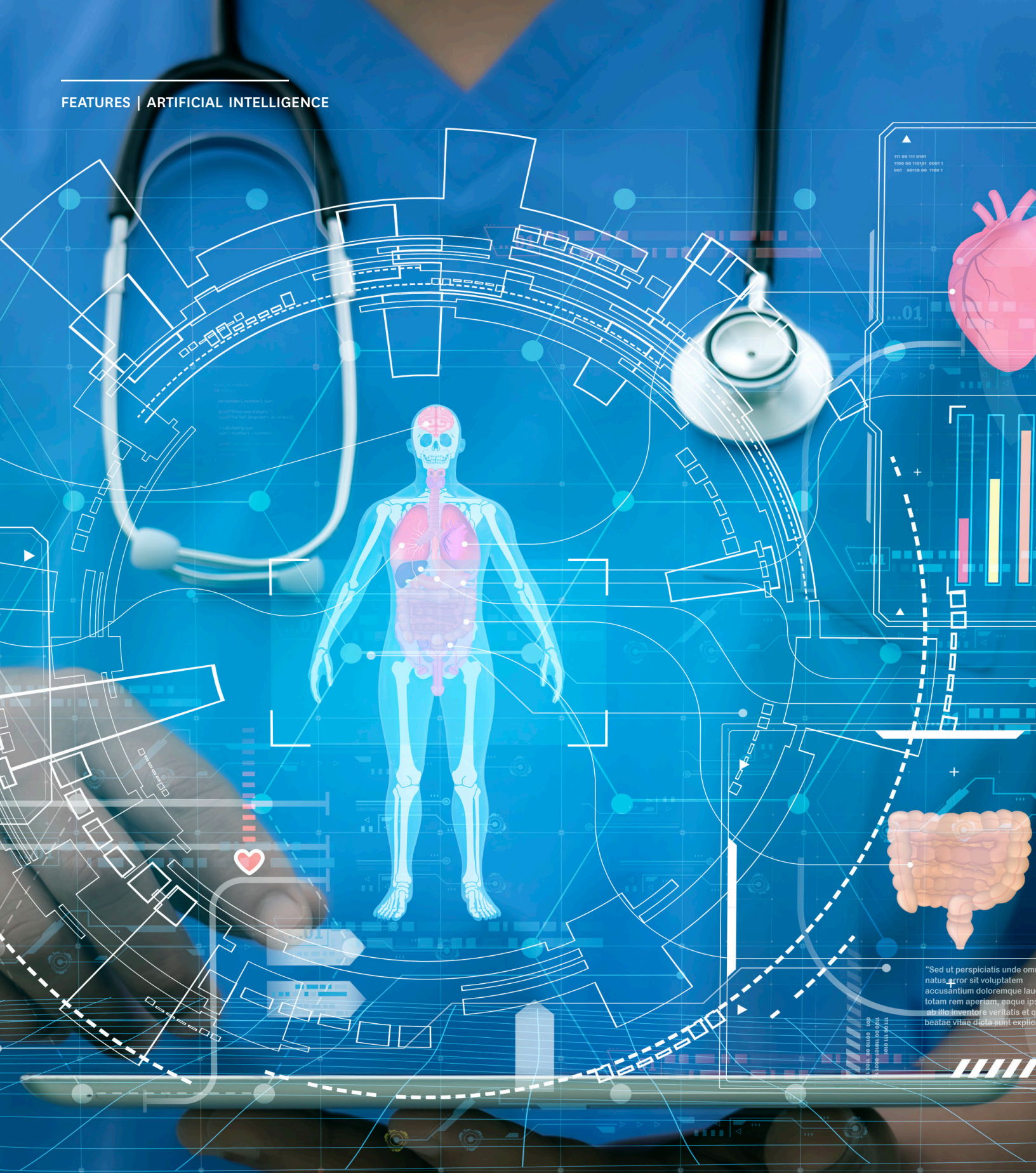


ILLUSTRATION BY **TOOWONGSA ANURAK/ISTOCK**

THE PROBLEM Healthcare faces urgent challenges that call for new knowledge and methods	**OUR SOLUTION** Create advanced AI tools designed specifically for critical health needs	**WHAT'S NEXT** Apply ISI's expertise through innovation and collaboration to transform healthcare

$1M investment to fuel *AI for Health*

BY JULIA COHEN

"ISI has been working in the health area for many years," said Yolanda Gil, reflecting on ISI's leadership in managing large-scale data through National Institute of Health (NIH) centers totaling $85M in funding. Now, as director of ISI's Center on Artificial Intelligence Research for Health (AI4Health), Gil is set to accelerate AI research advances to solve pressing health challenges by leveraging ISI's depth and breadth of expertise in AI. A recent $1 million award from USC's Frontiers of Computing initiative will help drive this mission.

"Now is the right time to make a major push in the area of AI and health," said Craig Knoblock, the Keston executive director of ISI. "There are important health problems to be solved, and AI has matured to a point where there are many opportunities where it can be naturally applied." The challenges, he said, "are getting the right people together from both the AI side and the health side, and finding the right problems to focus on."

As ISI's Senior Director for Artificial Intelligence and Data Science Initiatives and an ISI Fellow, Gil sees AI4Health as a collider of talent, connecting AI researchers with clinicians and health practitioners who want to push the envelope of AI advances for their field.

PROMOTING HEALTHIER LIVES WITH AI

"We're doing research on a broad range of areas that affect our health beyond doctor visits—how to improve nutrition, exercise, and recovery; prevent stress; and help people follow treatments and take medication properly," Gil explained. "We study people's behaviors and actions in all these aspects of health, but also their attitudes and degree of awareness," emphasizing AI's untapped potential in helping people understand what small changes in their daily routines can meaningfully improve their long-term health.

The center's data efforts include improving fairness, equity, and accessibility of care; tackling the challenges of multimodal information — such as text, images, and medical records; and federated learning, which allows AI to be trained on health records without compromising individuals' privacy.

Another key aspect of AI4Health's work is making AI-ready data. "Data isn't just tables. It's dynamic images, it's time series, it's physical objects, it's medical concepts, all connected together," said Gil. "These connections enable AI to get the full picture and discover critical causal knowledge."

Gil is passionate about the transformative potential that AI technologies hold. "AI is ready to have a positive, profoundly transformative impact in the world and we can't run away from that," she said. "If an AI algorithm can diagnose cancer years before a human radiologist can, the irresponsible thing is to not deploy the AI." ■

THE PROBLEM Finding in-network doctors is frustrating due to outdated healthcare search tools	**OUR SOLUTION** Using AI-powered semantic search to enhance doctor search accuracy by 20%	**WHAT'S NEXT** Conditioning users to try more diverse and complicated healthcare searches

Engineering a better way to find doctors

BY STEPHANIE LEE

For many, frustration with the American healthcare system begins with the very first step: finding doctors. Although most health plans offer online directories to search for in-network providers, these tools often fall short in connecting patients with comprehensive care options.

Now, Kaiser Permanente, a health consortium with thousands of doctors in its network, has teamed up with researchers at ISI to improve the quality of its search application using AI. The team engineered a new version of Kaiser's "Find Doctors and Locations" tool, one that uses a semantic search engine to deliver higher-quality results.

"We present a novel approach to an under-studied, but high-impact, search problem in the healthcare domain," Kaiser researchers wrote in the paper. "We implemented and deployed an advanced knowledge graph-based pipeline drawing from best-of-breed AI and data analytics research." Compared to the previous system, the novel tool improved patients' chances of finding a doctor in their region by 20%. The researchers presented their findings at the 47th International ACM SIGIR Conference in July 2024.

Previously, Kaiser's Find Doctors and Locations tool utilized a string-based search engine, which worked by matching the exact keywords entered by the user to the information available from the provider.

But string-based search proved inadequate for the complex world of medicine jargon. If a patient misspelled a specialty, searched via their symptoms ("chest pain" versus "cardiologist"), or resorted to colloquial terminology ("kidney doctor" versus "nephrologist"), the system returned incomplete or irrelevant results.

BUILDING A HEALTHCARE KNOWLEDGE GRAPH

Enter semantic search, a type of AI that can understand the context and relationship between words in a query. At the core of this system is what is known as a knowledge graph, a network that represents real-world entities — such as doctors, locations, specialties and symptoms — as well as the relationship between them.

In a user query, the system then matches the keywords (e.g. "kidney") to the relevant categories within the healthcare knowledge graph,

PHOTOGRAPHS BY **CHINNA PONG/FAT CAMERA/BET NOIRE/ISTOCK**

providing users with better results than directly comparing text. "We like to say that a knowledge graph represents things not strings," Mayank Kejriwal, an ISI research lead who worked on the study, said.

Researchers built the healthcare knowledge graph using data from various sources, including the Kaiser Permanente Find Doctors & Locations API, electronic health records and user search logs. The team also employed OpenAI's ChatGPT to map body organ terms to relevant medical specialties, further enriching the knowledge graph's semantic network.

To evaluate the effectiveness of their search engine, the researchers conducted an experiment using real query logs from Kaiser's system. The results were promising. When combined with the current Find Doctors & Location system, the semantic-based search engine provided relevant results for more than half of the queries, demonstrating a significant 20% advantage over the baseline system.

"A case study in using AI research traditionally applied in domains such as e-commerce and generic web search, with the goal of serving the needs of patients."

RESULTS IN MILLISECONDS

Semantic search also helped the researchers achieve real-world deployment. "A very challenging aspect of the system is that it has to work in real time," Kejriwal explained. "There are a lot of great algorithms out there, but it's very difficult to implement them on a real website where you get results quickly."

With complex deep neural networks or large language models, it may not have provided the fast response times that real users expect from a search engine, possibly discouraging adoption of the new tool.

But Kaiser's new tool works quickly, capable of returning results in milliseconds. The health network publicly deployed the new version of the Find Doctors & Location application on their website at the end of 2023, and it has been utilized by over 12 million users.

"We hope our implementation can serve as a case study in using AI research traditionally only applied in domains such as e-commerce and generic web search, with the goal of serving the needs of patients," they wrote.

The researchers believe that the improved search quality could have a long-term impact on patient behavior. Previously, discouraged by poor-quality results, patients might have abandoned searches for what they truly needed. ■

THE PROBLEM Identifying authors of anonymous text is vital for accountability but violates privacy	**OUR SOLUTION** Detecting authors via unique writing styles and developing tools to safeguard anonymity	**WHAT'S NEXT** Expanding to multiple languages, detecting short-text, and balancing privacy concerns

Uncovering *hidden authors* with AI

BY STEPHANIE LEE

ISI computer scientists are developing language technologies that could potentially identify who wrote anonymous text.

A cutting-edge AI research program to unmask anonymous authors is underway at USC Viterbi's Information Sciences Institute. Supported by a recent grant from the Intelligence Advanced Research Projects Activity (IARPA), it could have sweeping implications for online communication, spanning from misinformation to privacy rights.

The project, dubbed SADIRI (Stylometric Authorship Discernment & Interpretation for Realistic Inputs), aims to advance the field of authorship attribution — the process of identifying the individual behind anonymous written works — using language AI.

"There has always been a reason to know who wrote things that are anonymous," said Elizabeth Boschee, associate director of ISI's AI Division and principal investigator (PI) of the SADIRI project. "But with the volume of information in today's world, it's really a new frontier."

AUTHORIAL FINGERPRINT

Recent high-profile cases have already demonstrated the power and potential of machine learning techniques to unmask who is behind harmful and anonymous online content. For instance, in 2022, AI analyses of writing styles helped computer scientists reveal the identities of the true authors behind the far-right QAnon conspiracy leader, named Q, ending years of speculation.

The SADIRI program aims to further enhance these kinds of authorship attribution techniques, expanding the capability to include multiple languages and differing lengths of text. The technology works by using text data to generate an "authorial fingerprint" that represents an author's unique writing style rather than content. Many language forensics tools focus on identifying the latter, including common words, phrases or topics, making them ineffective if an author shifts subjects. But SADIRI aims to overcome this by developing an AI system that analyzes subtle patterns of stylistic elements that can only be picked up by a machine looking at hundreds of thousands of examples; for example, the use of commas, bullet points, or passive voice. This enables the technology to recognize an author's stylistic fingerprint across any type of content or subject.

CAN TRUE ANONYMITY EXIST?

In its first phase, the program has already achieved promising results, accurately identifying the authors of 350-word English-language text documents, roughly the length of a short news article.

But the team has bigger goals for the future, including expanding capabilities to multiple languages, such as Spanish,

ILLUSTRATION BY
JAYESH/ISTOCK

Russian and Chinese. They also strive to maintain accuracy with much shorter text samples — potentially even tweets.

If successful, the technology could open up powerful new applications for cyber forensics to intelligence gathering, while also addressing ethical concerns around civil liberties and privacy rights.

"One of the most concerning issues of the modern world is whether true anonymity can exist anymore," Boschee said. While anonymity can facilitate harmful behavior, it also plays a vital role in safeguarding individuals who speak out against oppressive governments, criminal groups and so on.

To address this, SADIRI has a complementary focus on developing authorship anonymization methods — sophisticated algorithms to help writers mask their identities from machine detection. The technology will play a similar role to a voice distorter, but for text.

BALANCE BETWEEN ACCOUNTABILITY AND PRIVACY PROTECTION

Though authorship anonymization may sound counterintuitive to the goals of attribution, simultaneous progress must exist between the two capabilities in order to maintain a delicate balance between two essential objectives in the digital world: accountability and privacy protection.

"As one system gets better, then the other system has to get better in order to protect against it," Boschee said. "Hopefully it becomes a virtuous cycle, where all the technology is getting better all the time."

The SADIRI program is a collaboration between ISI, which is part of USC Viterbi school of Engineering, University of Michigan, University of Maryland, and University of Birmingham. The first phase of the project was completed in June 2024. ■

PHOTOGRAPH BY **ROBINOLIMB/ISTOCK**

Safeguarding Online Discourse

BY STEPHANIE LEE

"Humans' true superpower lies in our ability to coordinate with each other through systems and networks that enable collective learning and problem-solving," says Adam Russell, ISI's AI division director.

But this superpower now faces serious risk from the destabilization of online ecosystems. AI-generated synthetic content, and misaligned AI-powered agents, platforms, and algorithms are corroding society's ability to collaborate in critical areas, including science, markets, democracy, and governance. And the internet, increasingly overrun with flame wars and conspiracy theories, has made the struggle to separate fact from fiction an everyday problem.

Across ISI's AI division, researchers are tackling this digital dilemma head-on. From unraveling the roots of polarization to detecting and mitigating foreign influence campaigns, the team spent 2024 leveraging cutting-edge tools and behavioral analysis to safeguard online discourse.

"ISI has committed itself to doing what we can to help make AI an ally — and not just an attacker — in efforts to preserve our superpower of coordination," Russell said. "We'll need this more than ever heading into our truly uncertain future."

UNDERSTANDING DIVISIVE CONVERSATIONS

From elections to abortion to global conflicts, it often feels like society inhabits two entirely separate realities. ISI researchers are analyzing how these divides form and whether common ground can be found.

Ashwin Shreyas Mohan Rao, a research assistant at ISI, examined over 3.5 million tweets about abortion rights after the Supreme Court's 2022 Dobbs decision, which overturned Roe v. Wade and ended the federal right to abortion. His findings shed light on how people discussed one of the most divisive issues in the United States. Conservatives framed abortion arguments around religion and fetal personhood, while liberals focused on bodily autonomy and women's health. Both sides mirrored each other's hostility, especially after major events.

Yet Rao's study also revealed a surprising point of overlap: exceptions to abortion bans in cases of rape, incest, or threats to the mother's life.

THE PROBLEM Toxic online discourse fuels polarization, distrust, and violence	**OUR SOLUTION** Monitor and analyze controversial topics across social platforms	**WHAT'S NEXT** Create computational tools and strategies to protect the integrity of online media

PHOTOGAPH BY **RAWPIXEL/ISTOCK**

This rare commonality could pave the way for more productive conversations.

"Exceptions are where survey studies have shown that there's more willingness to come across the party lines," Rao said. "I think that is the only way to solve ideological divisions — giving people hope that there's a bridge across two groups."

TRACING THE ROOTS OF ONLINE HATE

Understanding the spread of online hate —and its alarming consequences — is another focus in ISI's AI division. By mapping these pathways, researchers are illuminating how hate metastasizes across digital spaces, offering insights that could inform solutions.

Keith Burghardt, a computer scientist at ISI, has tracked disturbing trends on major platforms. In one study, his team documented the rise of hate speech on X; in another, they uncovered how users navigate between hate-based groups on Reddit. "We found that those who join one hate subreddit are about twice as likely to join other types of hate groups, ranging from racism to sexism to anti-LGBTQ groups," Burghardt said.

Burghardt's current research focuses on tactics to reduce harmful online rhetoric. After finding that challenging hate speech online — a tactic called counterspeech — is often ineffective, Burghardt's team is now exploring the possible integration of psychological methods with large language models to develop more effective and potentially automated mitigation strategies.

"We need more research into strategies that reduce the chances of people going down a deeper rabbit hole," he said.

NEW TOOLS FOR A SAFER INTERNET

Other innovative solutions to safeguard online discourse are emerging across ISI's AI division. Mahyar Khayatkhoei is developing a scalable method to detect deepfake videos; Kristina Lerman and Patrick Gerard are designing computational frameworks to quantify online "othering"; Luca Luceri has introduced a novel model for detecting influence campaigns across social media platforms.

One of ISI's most ambitious initiatives comes from Luceri and Emilio Ferrara, a USC professor and ISI principal scientist. Over the next few years, his project, called the Election Integrity Initiative, will help protect democratic processes from malicious interference by monitoring and analyzing online media in quasi real-time.

Findings will be released as technical memos and public datasets, which can be found at https://election-integrity.online/, fulfilling the team's mission to empower other researchers and inform policymakers. Additionally, this comprehensive data collection effort aims to extend beyond traditional platforms like X to include TikTok, Telegram, Reddit, and niche forums like Gab and Truth Social.

In 2024, the project team worked on data from the U.S. Presidential Election. Going forward, it will track geopolitical events around the world and provide resources to safeguard elections.

"We are keeping our eyes peeled to understand what types of influence operations are happening," Ferrara said. "This includes which ones are most effective, what tools threat actors are using to manipulate public perception, and what countermeasures might work." ■

THE PROBLEM Geoscience research often lacks accessible, reproducible methods and data sharing	**OUR SOLUTION** Equip geoscientists with open-source tools for more reproducible, accessible research	**WHAT'S NEXT** Future LinkedEarth trainings will support a more open, collaborative geoscience field

Enter the *geoscience*

BY JULIA COHEN

Ancient rocks from the Southern Ocean; satellite images of the Earth's atmosphere; soil samples from the Mojave Desert trenches. The 18 geoscientists who gathered for the first FROGS (Facilitating Reproducible Open GeoScience) workshop at ISI, held June 3-6, 2024 may study a wide and diverse range of data sources, but they came with a common goal: to learn how to level up their research, data sharing, and publishing techniques.

Participants like Jhon Mojica, a senior researcher at the University of Miami working with NOAA (National Oceanic and Atmospheric Administration), got an introduction to Scientific Python and R programming languages. Mojica said, "I'm leading projects on the expansion of Port Everglades and water quality around South Florida. Learning to use Python to automate data processing will make our studies more robust and efficient."

SETTING SAIL WITH PYRATES

They were taught methods such as spectral analysis to interpret environmental variability over different timescales. Pranaykumar Tirpude, a Ph.D. student at the University of Delaware whose research involves studying 1.4 million years of data from the Southern Ocean said, "Implementing these techniques will help me better understand climate cycles and the stability of ice sheets over geological time."

The workshop was hosted by LinkedEarth, an initiative that brings together AI and paleoclimate research.

This particular curriculum, dubbed PyRATES (Python and R Analysis of Time SerieS), catered to researchers with little to no experience in computer programming languages and was led by Deborah Khider, paleoclimatologist and Research Scientist at ISI; Julien Emile-Geay, Professor of Earth Sciences at USC Dornsife College of Letters, Arts & Sciences; and from Northern Arizona University's School of Earth and Sustainability, Associate Professor Nick McKay and Data Scientist David Edge.

Khider, Emile-Geay, McKay and Edge set out with the goal of elevating participants' research to the next level by equipping them with advanced techniques that were previously beyond their reach, and helping them apply

open-source era

FROGS WORKSHOP AT ISI, HELD JUNE 3-6, 2024
PHOTOGRAPHS BY **USC/ISI**

these methods to a broader array of datasets than previously thought possible.

Khider explained, "We wanted participants to come out with the skills to do their science using open source libraries while sharing their own project openly and in a reproducible manner."

In addition to the advanced research methods, FROGS participants were taught best practices for FAIR (Findable, Accessible, Interoperable and Reusable) science publishing. They learned techniques for data versioning, managing metadata, using open data repositories, and applying appropriate licensing. These skills improve reproducibility and collaboration, making data and findings easily shareable and accessible, meeting evolving standards in journals and funding agencies.

BUILDING A COLLABORATIVE FUTURE

The workshop not only equipped participants with new technical skills but also fostered a sense of community and collaboration. The interdisciplinary nature of the event brought fresh perspectives to geoscientific challenges, inspiring innovative approaches and potential collaborations.

As the researchers return to their respective sub-fields equipped with new capabilities in open-source programming and FAIR principles, the hope is that the effects of this workshop will influence the broader geoscience community. ■

LinkedEarth explained

Launched by ISI and partners—the USC Dornsife College of Letters, Arts & Sciences and Northern Arizona University—LinkedEarth combines AI with geoscience to make climate data more standardized, accessible, and usable. Founded in 2016 with support from the National Science Foundation, LinkedEarth equips geoscientists with tools, data standards, and training to analyze diverse sources like ice cores, tree rings, and sediment layers. By unifying data practices across these subfields, LinkedEarth enables researchers to work more efficiently and collaborate on shared challenges.

Through specialized training programs, LinkedEarth teaches scientists essential programming and data-sharing skills, helping them create research that is both reproducible and openly available to the wider scientific community. This initiative is building a cohesive ecosystem for data-driven insights into Earth's climate history, ultimately supporting a deeper, collective understanding of long-term climate patterns.

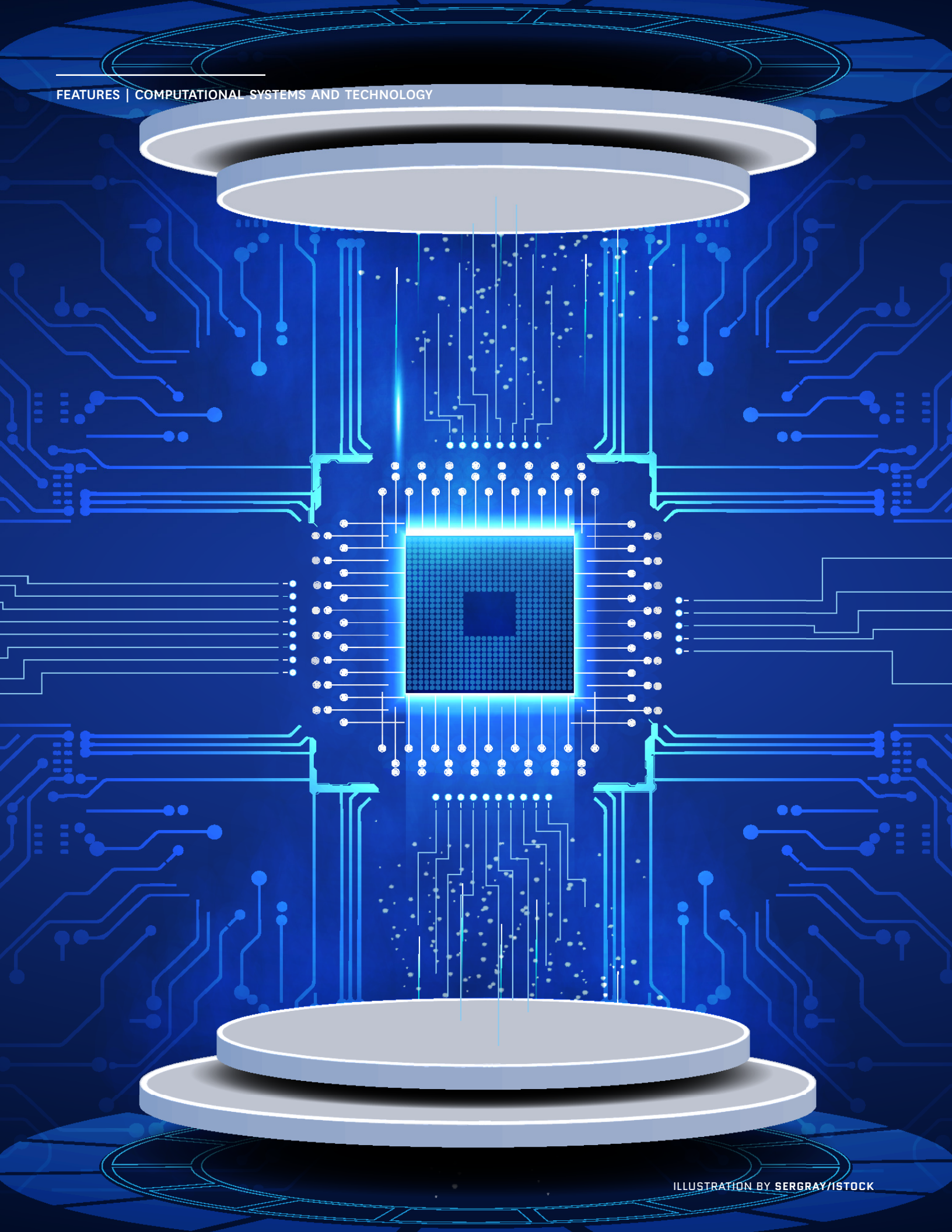


ILLUSTRATION BY **SERGRAY/ISTOCK**

THE PROBLEM The U.S. needs to advance semiconductor technologies and lab-to-fab prototyping	**OUR SOLUTION** Two major CA DREAMS projects in GaN and phased arrays, led by Northrop Grumman	**WHAT'S NEXT** Deliver prototype-level demonstrations for both projects within the next year

Two projects accelerate CA DREAMS

BY STEPHANIE LEE

CA DREAMS, led by the USC Viterbi School of Engineering Information Sciences Institute (ISI), continues to play a critical role in positioning the United States as a global leader in the microelectronics industry, especially when it comes to defense applications.

For its second year of operation, the coalition will focus on two major projects to advance semiconductor technologies and demonstrate lab-to-fab prototyping. One aims to develop a next-generation semiconductor material known as gallium nitride (GaN), which is used for high-power RF electronics, military radar, and advanced communications functions imaging and optics. The other aims to create advanced prototypes for faster, more reliable next-generation wireless networks. Technology innovator and leading global aerospace and defense technology company Northrop Grumman is partnering with CA DREAMS hub to oversee the projects' execution.

The Department of Defense (DoD) is supporting the projects with $31.9 million in funding, announced in September 2024. CA DREAMS — which stands for the California Defense Ready Electronics and Microdevices Superhub — is one of eight regional innovation hubs established under the DoD Microelectronics (ME) Commons Program, which is funded by the CHIPS and Science Act of 2022. The hub brings together partners across the Southern California region that include research universities, DoD semiconductor fabrication facilities, and numerous small businesses. Together, they will unite their resources and technologies to enhance how microelectronics move from laboratory to production.

"This investment enables Southern California's innovators to work together in new ways," said Yannis C. Yortsos, dean of the USC Viterbi School of Engineering. "We are bringing the best minds together to solve some of the hardest problems under the Chips and Science Act."

But these two funded projects represent more than just technical innovation — they're building a new model for development itself. The goal of the ME Commons Progtam is to accelerate domestic microelectronics hardware prototyping. By bringing together the full power of its hub partners, CA DREAMS aims to cut traditional development times in half. "Accelerated development is only possible because of this intimate and concentrated collaboration between industry, academia and commercial partners," said Randy Sandhu, director of manufacturing and science technology at Northrop Grumman's Microelectronics Center. "Being able to work at this level, with

"Being able to work at this level, with this amount of focused effort and resources dedicated to the projects — that's what's going to make us successful," said Randy Sandhu of Northrop Grumman.

this amount of focused effort and resources dedicated to the projects — that's what's going to make us successful."

ADVANCED MATERIALS FOR EXTREME ENVIRONMENTS

The hub's first major initiative, with $16.2 million in funding, focuses on GaN technology, a compound semiconductor material that could transform the electronics we use in everything from cell phones to fighter jets.

Most of today's consumer electronics use silicon-based chips that fail under high heat and power levels — but GaN is different. It belongs to a class of materials known as wide-bandgap semiconductors, which can operate at very high temperatures and voltages. These unique properties make GaN a breakthrough technology for smaller, faster, and more efficient electronics. The material could improve everything from battery chargers to military systems that must operate in harsh environments like space or the deep ocean.

The challenge lies in manufacturing. Because gallium nitride materials require atomic-level precision, it is extremely difficult to produce them at scale. "These materials are very sought out, but we haven't been able to transition them out of the labs and into our fabs," Sandhu said.

To tackle this problem, the project aims to accelerate GaN technology development for defense applications, relying on a team of universities, defense manufacturers, and startups.

Using Northrop Grumman's expertise as a technology leader in wide-bandgap semiconductor technology since the 1990s, the initiative is taking a comprehensive approach to advance every stage of development — from growing the semiconductor materials to designing and packaging novel devices ready to be integrated into real-world defense applications.

And this innovation will happen fast, according to Alex Zamora, the project lead and RF/mixed signal department manager at Northrop Grumman. Whereas traditional DoD prototyping cycles have taken two or three years to demonstrate concept feasibility, the Northrop Grumman-led team aims to accomplish the same feat in under 12-months, enabled by the hub's MOSIS 2.0 service.

"We are thrilled to have Northrop Grumman leading the

INAUGURAL SITE VISIT OF THE DREAMS HUB AT NORTHROP GRUMMAN; DREAMS DIRECTOR STEPHEN CRAGO; HUB BRAINSTORM IN MARINA DEL REY.
PHOTOGRAPHS BY **NORTHROP GRUMMAN** AND **JON FISCHER**

technical execution of this critical project," Steve Crago, CA DREAMS director and associate director of ISI, said. "They are a leader in developing advanced GaN technologies, and their involvement in this hub and leadership on this project ensure that we can rapidly translate cutting-edge research from our university labs into deployable solutions for the Department of Defense."

ACCELERATING PHASED ARRAY PROTOTYPING

The second project, with $15.7 million in funding, focuses on developing phased array prototypes to accelerate the availability of advanced communication systems for 5G and 6G networks. Originally developed for military radar systems, phased arrays are precision antenna technologies that steer radio waves electronically. Today, they are increasingly used not only in defense communications but also in commercial applications like distance sensing for autonomous vehicles.

However, designing novel phased arrays presents challenges. As frequencies increase to meet the growing demands of 5G and future 6G networks, all the hardware components must be miniaturized to handle shorter wavelengths. This requires researchers to create tiny parts and precision fabrication processes — without sacrificing any of the device's functions.

To address this, the Northrop Grumman-led project is developing a unified set of tools and resources drawn from the hub's university nanofabs and defense fabrication facilities, which will be managed through CA DREAMS' end-to-end prototyping service, MOSIS 2.0.

When a designer or engineer interested in phased array development engages with the new toolkit, specialist engineers from the MOSIS 2.0 team, who are well versed in all hub capabilities, will oversee the development process to guide users in selecting the appropriate tools and technologies for their specific phased array applications.

Sandhu likened the process to working with LEGO blocks, where accessible and customizable components allow for faster prototyping. "We're accelerating the curve by providing a toolkit that people can pull from to design and build up their array structure," he said.

Phased array systems have traditionally required years of specialized development, but the CA DREAMS initiative seeks to shorten that timeline dramatically. "What would normally take five to 10 years, we're hoping to do in two to five," Sandhu said.

"This collaboration, enabled by ME Commons and CA DREAMS, will connect new levels of the microelectronics ecosystem and apply them toward diverse 5G/6G needs across future DoD and commercial systems," said Monte Watanabe, RF/mixed-signal assistant department manager, Northrop Grumman. The team has wasted no time getting started. They are aligned on next steps for 2025 with key milestones and planned tests."We're eager to see success when developing both projects and are working under ambitious timelines," Sandhu said. "Our goal is to deliver prototype-level demonstrations within the program's first year." ■

THE PROBLEM Transition semiconductor innovations from lab research to commercial production	**OUR SOLUTION** MOSIS 2.0, an engineering service organization for semiconductor prototyping	**WHAT'S NEXT** Scaling up the service to meet the needs of DoD, academic, and industry customers

MOSIS 2.0's *first* year

BY STEPHANIE LEE

In 1981, ISI launched a service that transformed semiconductor innovation. At the time, manufacturing experimental computer chips required producing an entire silicon wafer holding hundreds of individual chips — an expensive process costing tens of thousands of dollars.

MOSIS solved this problem by combining multiple customers' chip designs onto a single wafer, where each customer paid only for the portion they needed. This collaborative approach drastically reduced the cost of manufacturing test runs, enabling smaller organizations to innovate.

Over four decades, MOSIS delivered more than 60,000 integrated circuit designs and generated up to $10 million annually at its peak. Now, its successor, MOSIS 2.0, is advancing this legacy to address the next-generation of chip innovation.

BUILDING ON A LEGACY

The USC-led California DREAMS (CA DREAMS) initiative began reinventing MOSIS in late 2023. MOSIS 2.0 not only continues offering MPW services but also expands to a second core focus: prototyping compound semiconductors. These emerging materials outperform traditional silicon-based chips at high frequencies and power applications, making them critical for next-generation technologies.

The new capability is made possible by CA DREAMS' network of partners, including seven university nanofabrication labs and three defense industrial base (DIB) fabrication facilities across Southern California. "The advantage here is the geographic proximity of different facilities," MOSIS 2.0 Co-Director Rehan Kapadia said.

Whereas the original MOSIS shared wafers, MOSIS 2.0 shares processes, equipment, and expertise. If a tool fails at one site, another can step in. Process knowledge is also easily shared across the network, reducing barriers to innovation and enabling faster development of complex technologies.

BRIDGING RESEARCH AND PRODUCTION

The transition from lab-to-fab — moving experimental research into large-scale, reliable production — is a major challenge in chip making. For compound semiconductors, this process is particularly difficult due to the lack of standardized manufacturing methods and the need for specialized tools.

"There's a lot of R&D done in universities on new devices and materials to make analog chips," MOSIS 2.0 Director Mike Haney said. "But this process has been hindered because there was no mechanism for university labs to readily work with full fabs."

This is where MOSIS 2.0 offers solutions. In its first year, the team has streamlined the lab-to-fab transition through several efforts. First is the standardization of processes across partnerships, ensuring seamless project handoffs without delays or rework.

A TOUR OF NORTHROP GRUMMAN'S FOUNDRY IN REDONDO BEACH, CALIFORNIA.
PHOTOGRAPHS BY **NORTHROP GRUMMAN**

The service is also pioneering a digital transformation among its university nanofabs, which often lack the precision required for scaling innovations. By introducing AI tools, including industrial-grade data analytics and machine learning software, MOSIS 2.0 enhances equipment monitoring and process optimization. These tools detect issues in real time and help refine workflows.

Kapadia explained that using AI-enabled monitoring could halve the time required to develop new process flows. "This is unique," he said. "We're creating a combination of physical and digital infrastructure that will truly be able to accelerate not only early stage semiconductor prototyping, but also how that is transitioned to low-volume, mid-volume, and, ultimately, high-volume production."

ADMINISTRATIVE EFFICIENCY

Another way MOSIS 2.0 streamlines collaboration is by uniting multiple institutions under a single administrative framework. This approach could eliminate months of setup time for technical projects.

For example, when hub partner Northrop Grumman, a leading global and aerospace defense technology company, needed to test a new chip patterning process, they connected with USC's nanofabrication lab through MOSIS 2.0's pre-established channels. What would normally require months of legal agreements and process setup was completed in two weeks.

"It was just amazing to see the speed of this little project," said Augusto Gutierrez-Aitken, a fellow at Northrop Grumman. "The big difference here is that California DREAMS has already established all that collaboration infrastructure to begin with."

OPEN FOR BUSINESS

With its operations model in place, MOSIS 2.0 began accepting external customers in summer 2024 and launched its storefront in October. The program serves Department of Defense, academic, and industry clients, tailoring its service to their needs.

When a customer submits their project requirements, they are matched with a dedicated MOSIS 2.0 engineer to guide them through the development process. Simple fabrication runs follow a streamlined path, while complex prototyping projects receive customized support from experts within MOSIS 2.0 and its partner institutions.

Each project also contributes to a growing knowledge base, capturing intellectual property and process innovations that can be reused for future designs. "Instead of having to reinvent the wheel, customers can use something that already exists," Kapadia said.

In 2025, MOSIS 2.0 plans to scale up both its business and capabilities. The goal is ambitious: achieve self-sustainability within the next few years and generate $20 million in annual revenue. "We have a superb team, combined with the extensive resources within our nanofabs and fabs," Haney said. "If we can't do it, nobody can."■

PHOTOGRAPHS BY **NONGNUCH PITAKKORN/ISTOCK**

Edge AI: bringing *intelligence* closer to the action

BY JULIA COHEN

Artificial intelligence is shifting from data centers to our devices, enabling real-time processing on everything from smartphones to satellites. This shift — known as edge AI — decentralizes AI from the large-scale data centers that traditionally powered it. While AI has existed in devices for years, edge AI represents a significant evolution by embedding intelligence directly into devices at the "edge" of the network, where data is generated.

Edge AI allows devices to make real-time decisions without depending on a constant connection to the cloud; this increases speed and enhances privacy. By keeping sensitive data closer to where it is generated, it is less exposed to those who shouldn't have it; for example, cloud providers or bad actors that might intercept and decrypt it. As edge AI evolves, ISI researchers are advancing its capabilities with projects ranging from wildfire mapping to space exploration, helping to bring faster, smarter solutions where they're needed most.

TACKLING COMPLEXITY BY MAKING TRADE-OFFS

"The biggest challenge we encounter in AI at the edge is balancing computational efficiency with the ever-growing complexity of AI models," said J.P. Walters, research team leader at ISI's Computational Systems and Technology Division. This complexity stems from the models' parameters — the variables that algorithms adjust to learn from data. As the number of parameters increase, so do the size of the models and the computing power required to run them. In short, larger models (with more parameters) generally produce better results (e.g., more accurate inferences).

Moore's Law, a concept introduced in 1965, predicts that the number of transistors on a microchip will double approximately every 18 to 24 months, leading to exponential increases in computing power. However, Walters emphasized that "parameters are doubling faster than Moore's Law predicts for hardware

THE PROBLEM AI models are advancing faster than hardware can keep up	**OUR SOLUTION** Develop edge AI systems for real-time processing on small devices in dynamic environments	**WHAT'S NEXT** Future advancements will enhance AI's role in daily life, space exploration, and more

The project will bring advancements in environmental sciences, such as climate monitoring in urban areas.

advancements." In other words, AI models are advancing faster than the hardware needed to run them. This leads to one of the fundamental challenges of edge AI: managing the trade-offs inherent in processing data locally.

Walter's team works to balance power consumption, processing speed, and memory usage. "You can't just throw a massive AI model onto a small device without considering these factors," Walters explained. "We constantly aim to find the sweet spot where performance and efficiency meet without compromising too much on either side."

ANOTHER LEVEL OF COMPLEXITY: ADAPTABILITY

In addition to managing hardware constraints, edge AI must adapt to changing conditions in real-time. This is known as adaptive AI, and it allows models to refine their behavior based on dynamic environments. Connor Imes, a research computer scientist in ISI's Computational Systems and Technology Division who specializes in adaptive systems, explains: "In a data center, you always have power, cooling, and high-speed network connectivity. The systems there don't usually need to respond to dynamic changes." He continued, "In contrast, an edge environment is out in the real world—such as your phone or car — and it's subject to all the dynamics that you and I are accustomed to dealing with and responding to in real-time."

Andrew Rittenbach, a lead scientist at ISI, explained a recent ISI project in which adaptive AI was used for wildfire mapping, making on-the-fly adjustments to process data quickly while ensuring the accuracy needed for practical use. He said: "Our model takes an image that's collected by a satellite — from a camera or radar — and as output, it turns this highly complex image into a map of ones and zeros, where ones highlight where there's fire, and zeros are where there's no fire."

In this scenario, the ISI team tested the model on previously captured satellite and drone data, demonstrating how edge AI can prioritize speed and accuracy to deliver critical updates to ground-based incident commanders, showcasing its transformative potential in disaster management.

PUSHING THE LIMITS OF EDGE AI: FROM EARTH TO MARS

Edge AI has also taken flight beyond Earth, with ISI researchers collaborating with NASA to validate its potential in space. In 2021, NASA launched a miniature robot helicopter on Mars, powered by a Qualcomm Snapdragon processor. "We worked on the next generation of the Snapdragon processor used on the Mars helicopter. Working with NASA, we prototyped various AI algorithms for this analog of the Mars helicopter," Walters explained.

The Snapdragon processor, which includes an embedded GPU and digital signal processors (DSPs), allowed the team to explore the limits of what it could achieve in space. "We made interesting trade-offs between the GPUs and the DSPs and found that we could eke out more performance from the DSPs than the GPU, which was a bit of a surprise," Walters noted, demonstrating how ISI researchers are pushing edge AI to its limits, even in the harshest and most remote environments.

LOOKING FORWARD

As edge AI continues to advance, it promises to play an even larger role in our everyday lives. By bringing computational power closer to the data source, edge AI can improve the efficiency and effectiveness of technologies across a wide range of industries, from autonomous vehicles to wildlife monitoring. This shift will not only make AI smarter and faster but also extend its reach to areas where cloud connectivity is limited or non-existent. ■

THE PROBLEM The DoD needs novel development methods to accelerate innovation	**OUR SOLUTION** ISI worked with the DoD to implement agile: a concept that revolutionized Silicon Valley	**WHAT'S NEXT** The recommendations are being shared across the DoD, speeding up innovation

Mission Critical: **software**

BY STEPHANIE LEE

"In the Department of Defense (DoD), they develop systems that can't fail," said Mike Orosz, a research director at ISI, who has collaborated with the U.S. Space Force (USSF) for seven years.

To ensure reliability and security in new technology, the DoD relies on the acquisitions process — a meticulous methodology for managing the lifecycle of new products or systems. The workflow is "pretty drastic," Orosz explains. "You define everything up front, almost every line of code."

However, this thorough approach can slow development, jeopardizing technological relevance. Military projects, often funded in the billions, can take up to a decade to deploy — by which time evolving technologies and threats may render them obsolete.

REIMAGINING ENGINEERING WORKFLOWS

Orosz's team at ISI is exploring alternative approaches. "We're trying to apply industry best practices in the DoD acquisitions world," he said. "We identify what works, what doesn't, and make recommendations to the government on how they can improve development processes."

Central to their research is a concept that has revolutionized Silicon Valley: agile development. This methodology emphasizes flexibility, collaboration, and rapid iteration, and has become the gold standard in commercial software development.

However, adapting agile practices to defense acquisitions, traditionally governed by the rigid "waterfall" method, requires new guidelines. Waterfall's linear structure, where all requirements are defined upfront, leaves little room for feedback or adaptation.

For seven years, Orosz's team embedded within USSF programs, conducting case studies on spacecraft software for satellites. These studies compared three methodologies: traditional waterfall, a hybrid approach, and predominantly agile workflows.

CRITICAL SATELLITES

Satellites are vital to national security and daily life. GPS, a "dual-use" technology key to both national security and economic prosperity, supports defense, IT and cybersecurity, and economic systems while sustaining daily life around the world. "Space is the great enabler," said Brian Duffy, a senior systems engineer at ISI. "It allows global communications and critical

development for space

PHOTOGRAPHS BY **JANIE C. BROS/GORODENKOFF/ISTOCK**

military operations."

The ISI team examined three confidential software projects for spacecraft command and control, collaborating with USSF Guardians from Space Systems Command. They gained unprecedented access to contractor data, offering insights previously unavailable to government oversight.

For instance, in the waterfall project, bugs were typically discovered late, leading to delays and cost overruns. By contrast, agile workflows broke development into smaller stages, addressing bugs early and reducing risks.

AGILE BEST PRACTICES

ISI's findings include best practices to most efficiently manage agile projects within the USSF. One key takeaway is the value of upfront systems engineering — the process of planning and designing the system before development begins. While this mirrors waterfall methods, it benefits agile projects by populating initial backlogs, defining priorities, and identifying dependencies.

"Performing some systems engineering upfront allows us to populate the project backlog with initial work and define what the priorities are," Orosz said. "It can also help identify dependencies. In the Department of Defense, it's rare to work on a program that doesn't intersect with a number of other programs."

Maintaining a skilled and adaptable workforce is also critical. Turnover can disrupt timelines, especially in complex projects. "You need strong training programs and must anticipate some turnover," Orosz said.

Finally, agile projects require customized performance tracking tools, a capability that is necessary for continuous data monitoring. Current systems often lag by months or face cybersecurity concerns.

LASTING IMPACT

ISI's work could accelerate military innovation and strengthen the nation's technological edge. The team's recommendations are already shaping DoD acquisition practices. Their insights have reached the Secretary of Defense's office and are being circulated across the Pentagon's acquisition workforce.

"The military has a lot of smart people with great ideas," Orosz said. "We just need to move a little faster, and partnerships such as these help us pick up the pace." ■

THE PROBLEM Growing cyber threats demand better tools for realistic defense research	**OUR SOLUTION** SPHERE offers modular testbeds to replicate real-world cyber systems for research	**WHAT'S NEXT** Expanding capabilities to enhance simulations, AI-driven defenses, and accessibility

Cybersecurity through *real-world* experimentation

BY JULIA COHEN

SPHERE (Security and Privacy Heterogeneous Environment for Reproducible Experimentation), a groundbreaking cybersecurity testbed being built by ISI, Northeastern University, and the University of Utah, will help researchers tackle cyber threats that impact everyday life. "SPHERE will enable researchers to study realistic attacks and build realistic defenses," said Jelena Mirkovic, SPHERE's principal investigator at ISI.

Funded by an $18 million grant from the National Science Foundation (NSF) in 2023, SPHERE will offer environments that mirror critical infrastructure, from water treatment plants and power grids to smart home devices. The goal? To help cybersecurity experts understand and combat the complex threats facing our increasingly connected world.

THE STRUCTURE OF SPHERE

SPHERE's testbed design is modular, with specialized "enclaves" that replicate different kinds of infrastructure. Each enclave provides a unique environment where researchers can simulate cyberattacks and study real-world vulnerabilities. "We're building something that the research community wouldn't have access to otherwise," Mirkovic explained, underscoring the rarity and value of SPHERE's setup. One year into the four-year project, SPHERE currently has three core enclaves, two of which are operational.

The first is the General Compute Enclave. This backbone of SPHERE will provide thousands of compute nodes, making it a powerful environment where researchers can conduct experiments on virtualized infrastructure, supporting foundational cybersecurity research. Roughly one-third of the general compute infrastructure is operational and available to beta users.

The second is the Internet of Things (IoT) Enclave. Led by SPHERE researchers at Northeastern University, this enclave will host over 500 devices, including smart home gadgets like Alexa, sensors, and networked actuators. "They're building a huge lab of remotely accessible smart home devices, all in close proximity but needing isolation from each other," Mirkovic noted, emphasizing the complexity of the setup. Researchers here can dive into security and privacy risks that IoT technologies pose. One-fifth of the IoT infrastructure is installed and will open to beta users by mid-2025.

And finally, the Cyber-Physical Systems (CPS) Enclave is designed to replicate critical infrastructure such as water treatment plants, power grids, and traffic control systems. This enclave will use programmable logic controllers (PLCs) to allow detailed simulations of systems that are normally hard to access. The build-out of this enclave is set for Year 2.

These enclaves allow researchers to explore how different systems interact under various cyber threats. SPHERE's flexible design and user-friendly tools ensure that everyone, from students to experts, can run meaningful, realistic experiments and easily share their results with the cybersecurity community.

YEAR ONE'S ACCOMPLISHMENTS: GROWING A USER BASE AND EXPANDING OUTREACH

With approximately 120 researchers and over 1,000 students already using it, SPHERE got off to a "good, strong start with regard to serving users," said Mirkovic. SPHERE officially opened to beta users in July 2024, following a smooth transition from the legacy DETERLab platform. The DETER project (Cyber DEfense Technology Experimental Research) created and ran DETERLab, an earlier cybersecurity testbed designed to provide researchers with a controlled environment for simulating and studying cyberattacks and defenses. "Ideally, we'd like to have several thousand research users and perhaps 10,000 students per semester," Mirkovic added, emphasizing SPHERE's ambition to become an indispensable resource for the cybersecurity research and education community.

Different users have different needs, so SPHERE will have six specialized portals accessible through one interface. "The portals will support exploratory research, mature research, novice users, use in education, use by artifact evaluation committees, and use in human user studies," Mirkovic explained. Four of these portals are already operational, with tools that include interactive notebooks for researchers and streamlined interfaces for classroom learning.

One standout tool is the artifact evaluation portal, which lets conference participants reproduce research artifacts in a standardized format. As part of their outreach, the SPHERE team has partnered with major cybersecurity conferences, providing researchers with tools for validating findings while showcasing SPHERE's strengths in reproducible research. Over the past year, SPHERE's team has presented the testbed at more than 20 conferences and meetings, offering demos and building connections with potential users. An internship program also brought in eight students. The program gave students hands-on experience in tasks ranging from cabling to software automation and sparked interest in cybersecurity and testbed design.

YEAR TWO AND BEYOND

In its second year of this four-year project, the SPHERE team plans to make operational the Cyber-Physical Systems and IoT enclaves, welcoming new beta users. Additional programmable logic controllers and real-world scenarios will be added to the Cyber-Physical enclave, allowing studies on vulnerabilities in systems similar to those affected by recent infrastructure attacks. The IoT enclave will continue growing, giving researchers the opportunity to explore security and privacy risks in smart home devices and other interconnected systems.

To meet the growing need for AI-driven cybersecurity defenses, SPHERE will also add GPU-equipped nodes to support machine learning research. In Year 3, SPHERE plans to introduce edge devices to simulate security challenges in mobile and embedded systems, broadening the scope of potential research applications. Year 3 will also expand some SPHERE general compute servers with programmable network cards, allowing for experimentation that builds dynamic, in-network defenses. ■

PHOTOGRAPH BY GREMLIN/ISTOCK

PHOTOGRAPH BY **KAREL NOPPE/ISTOCK**

A cutting-edge solution for *secure 5G*

BY JULIA COHEN

In a world where everything from cars to coffee machines is connected through the Internet of Things (IoT), securing next-generation 5G networks is more important than ever. IoT links devices to the internet, creating endless opportunities — and vulnerabilities.

SABRES is a project by USC ISI and DARPA's Open, Programmable, Secure 5G (OPS-5G) program, which aims to secure 5G networks and prepare for future technologies like 6G. Led by ISI's Erik Kline, SABRES is redefining network slicing, a technology central to 5G, to make it faster, safer, and scalable.

WHAT IS SABRES?

SABRES — short for "Secure, Adaptive, roBust, Resilient, and Efficient Slices" — aims to address four key challenges in modern networking: efficiently allocating resources across vast networks, verifying the integrity of those resources, protecting data in transit, and mitigating risks associated with shared infrastructure.

At the heart of SABRES is a unique mathematical approach called conflict-based search (CBS). This method optimizes the allocation of virtual network slices, or segments of a physical network that are reserved for specific uses. Unlike traditional methods, which either scale poorly or compromise efficiency, CBS separates simple and complex parts of the problem, solving them individually. This not only accelerates calculations but also ensures better use of limited resources.

"We've really done something novel

THE PROBLEM IoT and 5G demand speed, security, and scale—traditional methods fall short	**OUR SOLUTION** A novel approach that combines state-of-the-art efficiency with real-world scalability	**WHAT'S NEXT** SABRES transitions to broader use, driving secure, efficient communications globally

A unique mathematical approach: a conflict-based search optimizes the allocation of virtual network slices.

here," said Kline, a principal scientist in the Networking and Cybersecurity Division at ISI. "We developed an algorithmic framework for the virtual network embedding problem that combines state-of-the-art efficiency with real-world scalability. That's not easy to achieve in this field."

SABRES improves upon existing methods by addressing network slices in parts: solving straightforward sections quickly and focusing computational power on more complex conflicts.

HOW SABRES TACKLES THE CHALLENGES OF 5G

Efficient Resource Allocation: Using CBS, SABRES calculates and embeds network slices efficiently while meeting constraints like bandwidth, latency, and security. This approach ensures that even large-scale networks remain manageable. "The embedding process is really tricky. You're mapping virtual resources onto physical ones while respecting constraints like capacity and latency," Kline explained. "The CBS method lets us optimize these mappings in a way that works across different scales."

Verification: SABRES verifies that allocated resources meet specified requirements. For instance, proof-of-work tests ensure nodes meet computational needs without leaking sensitive information. "It's not enough to allocate resources — you have to make sure they're doing what you expect them to, and that you can prove it," said Kline.

Obfuscation and Security: To protect sensitive communications, SABRES employs obfuscation techniques that prevent traffic patterns from revealing usage details. "Traffic analysis attacks are a real threat. Just because your data is encrypted doesn't mean someone can't infer something from how it flows," Kline noted. "We use obfuscation to close those gaps."

Cross-Network Scalability: SABRES enables secure communication across networks, a notoriously difficult problem in telecommunications. "Interoperability across different networks is incredibly hard," Kline said. "We've tailored the CBS approach to handle the complexities of working across domains, and we can do it in a trusted fashion."

REAL-WORLD APPLICATIONS

The work done by SABRES has wide-ranging implications. In a commercial setting, the principles of network slicing can create bespoke experiences, such as augmented reality at live stadium events. In more critical applications, such as defense, it enables secure, scalable communication between service members in remote locations and central command.

"In defense applications, it's not just about connecting Point A to Point B," Kline explains. "It's about doing so securely, ensuring that sensitive data isn't leaked or compromised, even if the infrastructure involves untrusted third parties."

THE TEAM LOOKS TO THE FUTURE

As the SABRES project nears completion, the team is focused on transitioning its breakthroughs to the broader community. Technologies developed as part of SABRES are already finding applications in related fields, from data center optimization to enhanced cybersecurity protocols. The SABRES team includes collaborators from telecommunications giant Lumen Technologies and cryptography specialists Duality Technologies. These partners bring unique expertise, helping SABRES transition its innovations into real-world applications.

In the larger scope of DARPA's OPS-5G program, SABRES exemplifies the initiative's goals: fostering innovation while addressing the unique security challenges of modern networks. "SABRES is about more than solving a mathematical problem," Kline emphasizes. "It's about ensuring that the networks we rely on are safe, scalable, and adaptable to the challenges of tomorrow." ■

Tackling privacy challenges in *robotaxis*

ILLUSTRATION BY **SCHARFSINN86/ISTOCK**

THE PROBLEM Existing privacy solutions are inadequate for emerging technologies	**OUR SOLUTION** Adapt and expand privacy patterns for new domains like autonomous vehicles	**WHAT'S NEXT** Foster collaboration between academia and industry to reinvigorate the field

BY STEPHANIE LEE

A decade ago, engineers, designers, lawyers, and regulators collaborated to address digital privacy challenges, resulting in the creation of 'privacy patterns' — standardized solutions to common privacy issues, similar to software templates. These patterns help developers embed privacy controls into their systems from the start, simplifying privacy engineering and making privacy-by-design easier to integrate into software development.

But the original set of privacy templates focused on issues for enterprises and websites. Today, the digital landscape has expanded. Privacy concerns permeate diverse domains such as banking, energy, automotive, and aviation. It raises questions about the applicability of existing patterns to new technological frontiers.

A BREAKOUT QUESTION

This concern caught the attention of a group of scientists at a 2023 Dagstuhl Seminar, a prestigious research event held in Saarland, Germany. "The question was asked: would these broader patterns designed for enterprises and websites apply in an automotive scenario?", recalled David Balenson, director of the networking and cybersecurity division at ISI, who attended the seminar.

Balenson and his colleagues embarked on a collaborative study to investigate the applicability of privacy patterns in emerging technologies. They focused on self-driving taxis, or robo taxis, as a case study within the broader 'mobility as a service' (MaaS) ecosystem, which includes transportation services, such as Waymo or Uber, that are accessible via a single platform.

In the study, researchers put existing privacy patterns to the test, examining their effectiveness against potential privacy threats. They found that while some threats could be mitigated, there are still some gaps, and patterns face several hurdles for real-world application.

To address this, the team contributed new ideas for how patterns could be better adapted and expanded to address unmet concerns. They presented their results at the 2024 International Workshop on Privacy Engineering.

"This research is crucial to shed light on privacy patterns as a major component to enhancing privacy in automotive applications and beyond," said Ala'a Al-Momani of Ulm University in Germany, the lead author of the study. "The work analyzes these patterns to bring them into better applicability among privacy professionals in a world where the demand for privacy is continuously increasing."

ANALYZING PRIVACY PATTERNS

The study began by identifying the various types of data available to different parties in a robotaxi scenario, which can be more complex than meets the eye. "The robotaxi has inward cameras, it has outward cameras," Balenson said. "It might look at streets, it might look at pedestrians, it may actually look at the rider."

This plethora of data could be used to improve service quality and ensure passenger safety. Yet it also has more invasive purposes, such as targeted marketing and personal identification, raising significant privacy concerns. "Without adequate regulation and controls, it's sort of like the wild wild west, where anyone and everyone collects whatever data they want in hopes to monetize it," Balenson said.

To analyze potential threats from the data collection, the team applied a privacy threat modeling framework called LINDDUN, which stands for linking, identifying, non-repudiation, detecting, data disclosure, unawareness, and non-compliance.

NEW NEEDS FOR DATA PROTECTION

The study found that service providers and vehicle manufacturers of robotaxis pose great risk to customer privacy, with the ability to collect, process, and potentially misuse vast amounts of personal data. Existing patterns were able to mitigate some but not all of these risks, leading the researchers to propose ideas for new privacy solutions.

"This research identifies the gap in the current privacy patterns landscape and proposes new privacy patterns to enable the development of privacy-preserving systems," Al-Momani said.

They identified three main issues to application: conflicts between privacy and necessary system functions, gaps in addressing new privacy threats unique to autonomous vehicles, and a lack of clear guidelines for developers.

"Our findings indicate that while patterns may be a suitable approach, further research is necessary to fully ascertain their efficacy and applicability," said Christoph Bösch of Bosch Research, a global engineering and technology company, who worked on the study.

Balenson aims to leverage ISI's resources and expertise to drive new innovation in this field. "This is a call for the community to step up and join us." ■

THE PROBLEM Society needs more secure, trustworthy, and robust networks	**OUR SOLUTION** Combine the fields of classical networking and quantum mechanical phenomena	**WHAT'S NEXT** Build practical, quantum-augmented hardware and software to improve today's internet

Strengthening networks with *quantum* technologies

BY STEPHANIE LEE

In fifty years, computer networks such as the Internet have advanced from academic curiosity to a fundamental infrastructure of the modern world. More recently, scientists have theorized that systems based on quantum mechanical phenomena could solve problems far beyond the reach of classical computers. Now, a research team led by ISI seeks to bring these two fields together, to create secure, trustworthy, and robust networks that meet increasingly critical societal needs.

A key aspect of the effort is its focus on real world impact. Rather than targeting a fully quantum internet, the team is building practical hardware and software to augment existing internet infrastructure with the unique properties of quantum mechanics. The goal is to deliver commercial-ready technologies within the next five years.

"We aren't exploring the very far away question of how to build networks that connect quantum computers together," John Wroclawski, project co-principal investigator and senior director for strategic initiatives at ISI, said. "Instead, our question is: can quantum technologies, as they exist today or in the near future, fundamentally improve the trustworthiness of current networks?"

The team, a collaboration between ISI, USC, NuCrypt LLC, MIT, and Northeastern University, calls their project AQUARIUS, an acronym for Accelerated Quantum Research Integration for Usable Secure Networks. They have received $18 million in support from the Defense Advanced Research Projects Agency (DARPA), announced in May 2024.

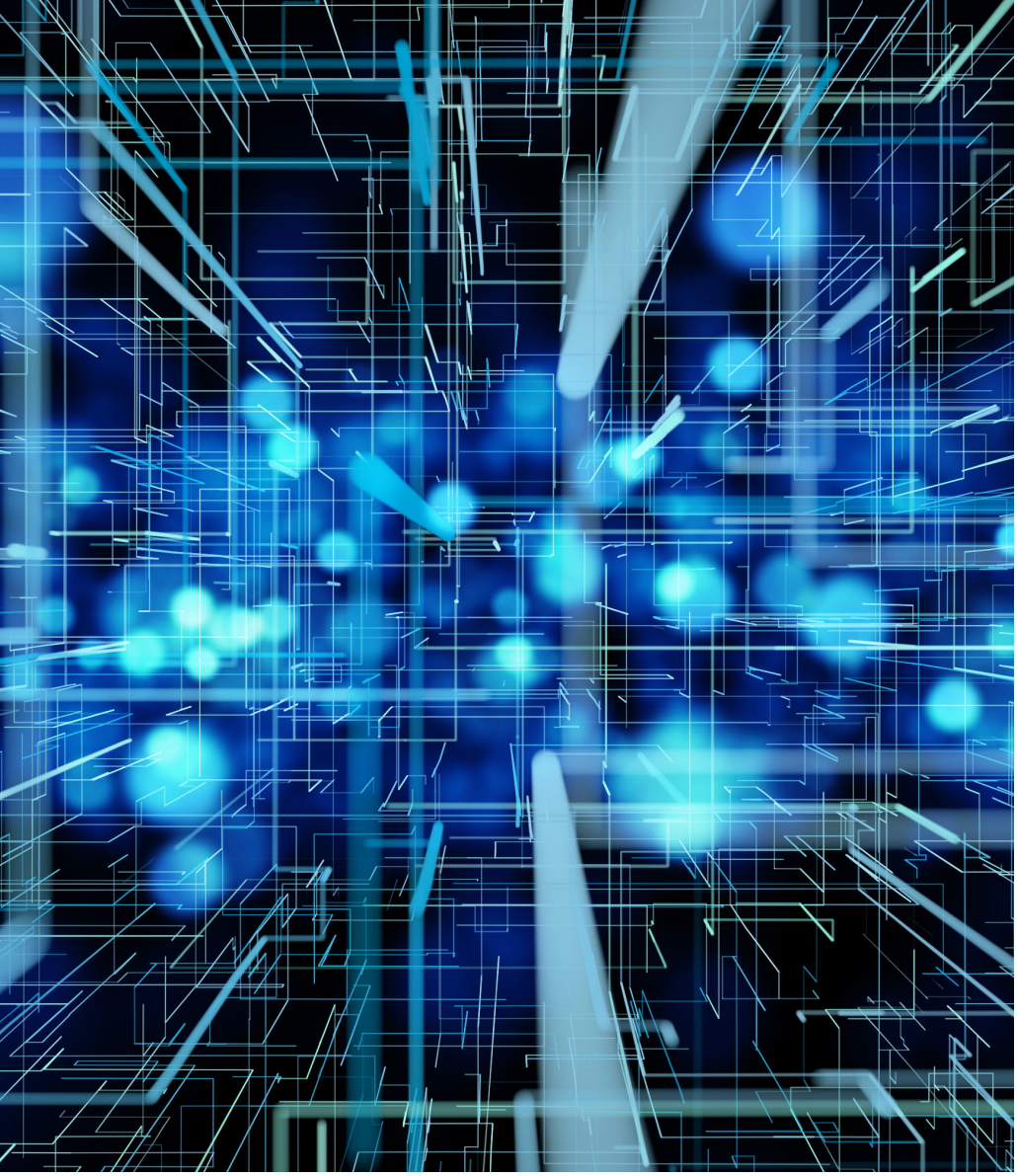
The funds will be used to develop two key innovations: a novel hardware component, known as a quantum-augmented network interface card, and a novel software framework to integrate this and other hardware into existing systems. Together, these technologies could enable what the researchers call "quantum-augmented networking" — a way to enhance classical networks with completely new security and trustworthiness properties not available through existing approaches.

A NEW KIND OF NETWORK INTERFACE

Central to the AQUARIUS project is the development of a quantum-augmented network interface card, or QNIC. In classical networking, standard network interface cards (NICs) connect devices such as PCs and servers to the internet. AQUARIUS's QNIC takes this concept further, integrating quantum functions into the NIC to enhance network security and performance.

The project investigators say that this is a completely new capability. "Nobody's ever built one of these before, nor knows what they're going to look like," Wroclawski said.

At the level of quantum physics, the QNIC achieves its functionality by leveraging what the team calls "practical quantum states"—weak states of laser-generated light that exhibit quantum properties. "These states are limited in capability compared to some other quantum approaches, but still offer essential properties for our application," explains Jonathan Habif, a principal scientist at ISI and project co-principal investigator. "In return, their huge



PHOTOGRAPH BY **METAMORWORKS/ISTOCK**

benefit is that no esoteric technology is required to work with them. A fundamental part of our idea is that we can build a QNIC today, with materials we can buy off-the-shelf," said Habif.

Stephen Schwab, a research director at ISI and project principal investigator, said that the QNIC could layer these properties over existing channels and connections, providing extra security for everything from Zoom calls to bank transfers. "Everyone's computers could potentially get quantum-augmented services with our solution," he said.

SOFTWARE THAT MAKES IT WORK

Hardware innovations like the QNIC are only part of the equation. To ensure seamless integration into existing networks, the AQUARIUS team is also designing a universal software stack. This framework decouples the functionality of the software from the design of the hardware — a concept known in computer science as abstraction.

"Abstraction layers hide the complexity of underlying systems, making it easier for developers to work with higher-level concepts without needing to understand the intricate details of a particular lower-level implementation" Wroclawski explained. "This is key, because it means our approach can support future QNICs and quantum augmented services, not just the ones we're building today."

This is already at play in today's internet. Web developers don't need to know the inner workings of various network cards to build websites. That abstraction helped the internet take off, making new innovations accessible and scalable. The AQUARIUS framework could have a similar impact on quantum-augmented technologies.

"The team wants to implement an overall software framework that facilitates rapid advancement and wide-scale deployment of quantum-augmented networking services," said David Balenson, interim director of ISI's networking and cybersecurity division, who is not involved in the project.

THE ISI LEGACY, IN ACTION

DARPA has funded multiple research teams to explore solutions for quantum-augmented networking. However, only the AQUARIUS team is tackling both hardware and software.

If successful, the software stack will unify all emerging prototypes, each with their own unique designs and functionalities, under one umbrella. This could enable disparate research teams to integrate their quantum-augmented technologies, including QNICs, into a cohesive system. In the future, it could also allow hardware to evolve and advance over time without requiring constant software changes.

That the AQUARIUS team is attempting to create both the QNIC and the universal software stack is a testament to ISI's history and leadership. The institute was instrumental in developing the classical internet and has remained at the forefront of networking and cybersecurity projects for decades. Now, this project, which brings together expertise from across ISI divisions, could help usher in the next generation of networks by combining the institute's networking and cybersecurity research with crucial support from its strengths in computing systems and technology.

"At ISI, there's a certain depth of knowledge about what it means to build a network," Schwab said. "It's part of the DNA of the institution." ■

THE PROBLEM Advances in studying complex proteins make capturing and archiving data more challenging	**OUR SOLUTION** Apply Deriva, a new approach to data management for capturing new protein structures	**WHAT'S NEXT** Enable breakthroughs in drug discovery and disease research with high-quality, AI-ready data

Many *proteins*, one data bank

BY BERNICE CHAN

Proteins work together in complex ways to support the processes of life, and their structures tell unique tales of functionality and purpose. Documenting these structures can unlock new avenues of biological knowledge, and researchers at ISI are currently contributing to these efforts. The Protein Data Bank (PDB) is a globally shared repository of data on macromolecular structures and their complexes.

Established in 1971, the PDB provides open access to structural biology data. PDB data was used to create and enable advances in AlphaFold, an AI system developed by DeepMind that can predict a protein's 3D structure from its amino acid sequence. ISI is now collaborating with members of the PDB to build the PDB-Dev repository that expands the capabilities of the PDB to archive macromolecular structures from novel and emerging methods.

Currently, Carl Kesselman, director of ISI's Informatics Systems Research Division, and other colleagues, have developed critical technology that facilitates the process of data entry into the PDB-Dev repository. The technology, Deriva, allows data insights to become more discoverable and more useful to scientists.

DISCOVERING PROTEIN STRUCTURES

One of the core problems in structural biology, which scientists have been investigating for around 40 years, is understanding the shape of proteins from their amino acids.

Historically, the only way to determine the tertiary structure of proteins was through crystallography. Rosalind Franklin's breakthrough research, which contributed to the discovery of the double helix structure of DNA in 1953, was facilitated by X-ray crystallography.

However, the process of crystallography is slow and expensive, and some proteins are not good candidates for crystal formation, which poses a problem for research. This is where AlphaFold comes in. After taking in the PDB's expansive data bank of information, AlphaFold was able to analyze and identify protein structures computationally instead of experimentally.

Even with AlphaFold's achievements, there still exists a growing need to examine more complicated structures and more complicated proteins and macromolecules with a new generation of techniques supported by PDB-Dev.

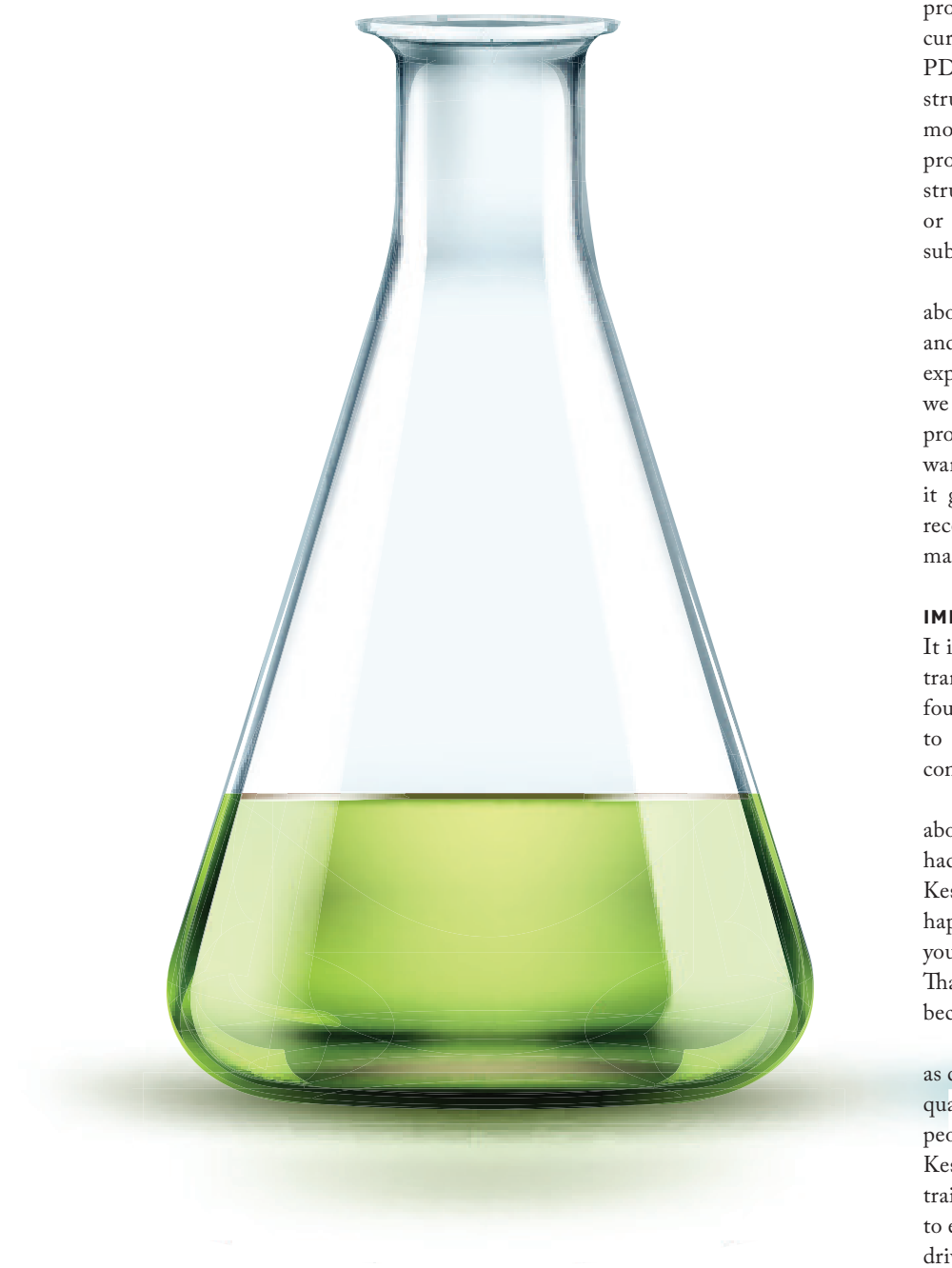


ILLUSTRATION BY **VALERIY MATVEYEV/ISTOCK**

ISI'S TECHNOLOGY AT THE FOREFRONT

ISI has a history of working with protein structures, previously joining the GPCR consortium to advance structural information about G-protein couple receptors.

This uniquely positioned Kesselman and his team to develop the PDB-Dev Data Harvesting System, which runs on the Deriva software that provides researchers with a platform to manage their scientific assets. "Our software plays a critical role in the PDB-Dev data processing infrastructure, supporting data collection, curation, validation, and dissemination. This allows the PDB-Dev repository to collect information about new structures and process and store them in the archive more easily. If you want to publish anything about protein structures in peer-reviewed journals, the structures you discovered have to be archived in PDB or PDB-Dev. ISI's software is crucial for the data submission process," Kesselman noted.

Kesselman is optimistic that ISI's efforts will bring about big leaps and bounds in understanding diseases and discovering new drugs, which would dramatically expand the scope of scientific research. "The technology we developed will play a huge role in expanding the protein data bank," said Kesselman. "Whenever scientists want to input their findings into the PDB-Dev system, it goes through our software. Members of the PDB recognized that ISI's tools are well-suited to flexibly manage data and enhance collaboration."

IMPACT ON THE QUALITY OF SCIENTIFIC DATA

It is important that the data in scientific papers remains transparent and reproducible. Especially if the data set is foundational, like the data in PDB-Dev, every entry has to be well-documented and citable so the scientific community can benefit from it.

"The New York Times recently published an article about how the Dana Farber Cancer Center at Harvard had to withdraw 12 papers because of fraudulent data," Kesselman recalls. "One of the ways to prevent this from happening is to have well-curated data that goes into your studies. If not, you're prone to errors or malfeasance. That's why repositories like the PDB-Dev are important, because they force contributors to validate their data."

This could also have implications for the future, such as developments in AI, which requires a baseline for data quality. "More globally, there is an issue of whether people can trust the data that goes into AI," said Kesselman. "AI is very dependent on high-quality training data. That's why ISI is part of the team helping to ensure better data entry into the PDB-Dev, which will drive future advances in research." ■

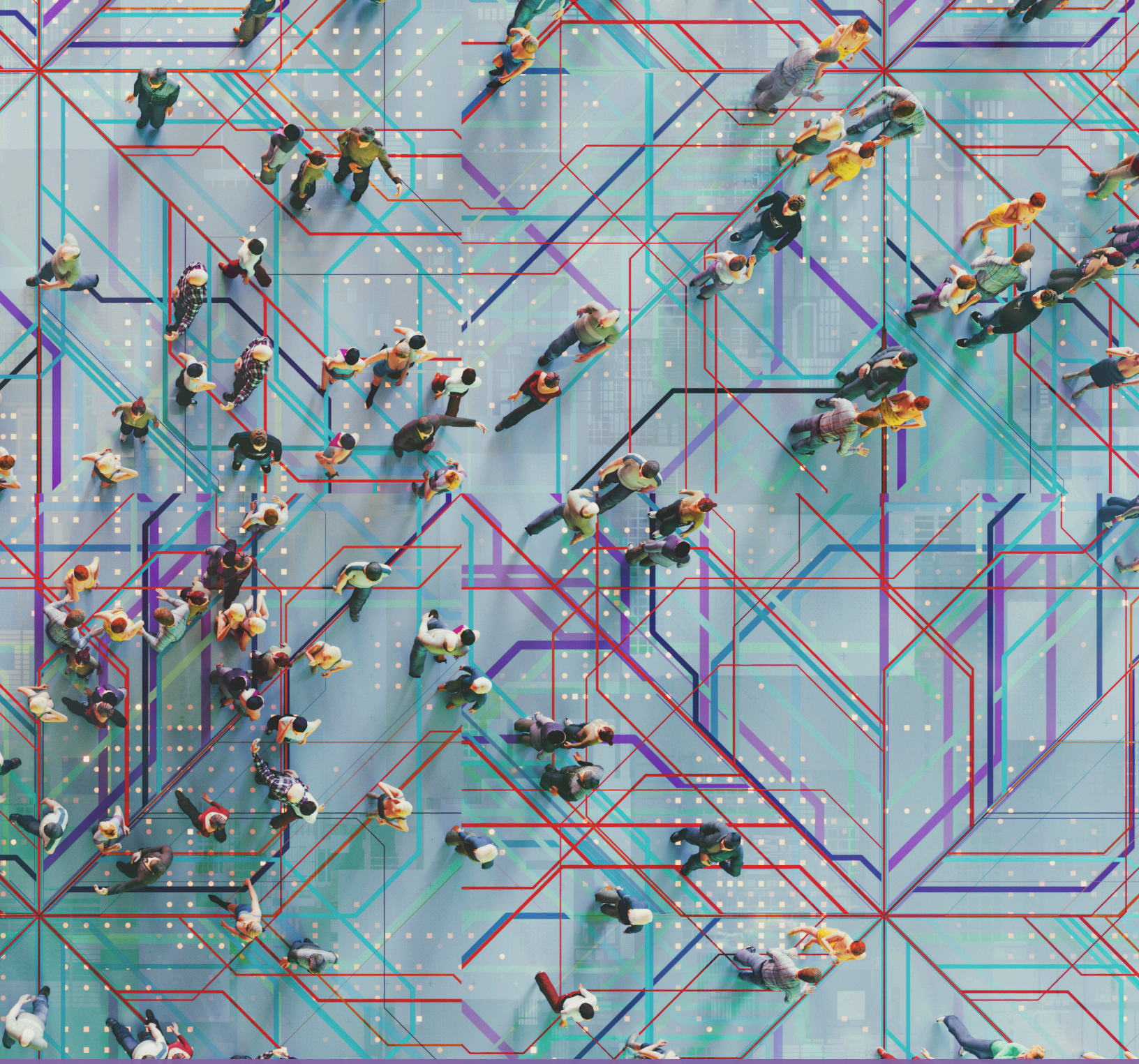
The PEOPLE of ISI

BY TERRY BENZEL

ASSOCIATE DIRECTOR OF ISI

At ISI, innovation is powered by people. Our institute is home to exceptional researchers who lead pioneering work in artificial intelligence, networking and cybersecurity, computational sciences, and beyond — and we are much more interdisciplinary than ever before. Traditional boundaries are replaced by teamwork across research areas, enabling breakthroughs that address some of the world's most complex challenges. This culture of curiosity and teamwork defines ISI as a premier organization for pioneering science and engineering.

But what facilitates this innovation is not just science, but the entire ISI staff. Beyond the researchers are the teams that keep the institute running: pre-award staff who ensure proposals meet rigorous standards, administrative professionals who manage travel and



events, the IT team supporting advanced computing, and research engineers who build products that we transition to our customers. The list goes on.

These individuals, often behind the scenes, play a vital role in shaping ISI's success. Whether it's coordinating meetings for new projects, streamlining reimbursement processes, or troubleshooting technical issues, they make it possible for researchers to focus on discovery. ISI is a true community — one where every contribution matters.

ISI's core values are research excellence, integrity, and transparency. Personally, I also add another value: caring for our people. No matter what someone's role is, we seek opportunities for acknowledgment and growth. Because when people are supported and empowered, the entire institute thrives. ■

ILLUSTRATION BY **GREMLIN/ISTOCK**

The *new generation* of ISI Ph.D.s

TEXT BY **BERNICE CHAN**
PHOTOGRAPHS BY **ANGEL ITUA**

They came for the world-renowned supervisors and projects of global significance. While achieving great strides in research, the 2024 ISI Ph.D. graduates learned a lot more than science, with soft skills such as collaboration, and asking for help when stuck. Seven of them recall their years at the institute, and how ISI has impacted the way they approach research. Some are headed for careers in big tech, while others dream of continuing their journey in academia. All will remember the breathtaking views of the Marina that inspired their long research story, and friends they will keep for a lifetime.

Basel Shbita

Basel Shbita received his Ph.D. in Computer Science in May 2024, and he was supervised by Craig Knoblock. He grew up in a small Palestinian community, earning his bachelor's degree in electrical engineering at Tel Aviv University in Israel. He worked at Mellanox Technologies, a supplier of computer networking products that was eventually acquired by NVIDIA. After that, he worked on storage devices on Apple's iPhone and MacBook until he moved to LA to come to USC.

WHY DID YOU CHOOSE A COMPUTER SCIENCE FIELD?

Computers have been my best friend since I was 10. Google didn't exist back then, so I was curious about source code, HTML and how it was executed on the server. After being promoted to a senior engineering position at Mellanox, I was exposed to more web protocols as my work was about designing network devices. I became intrigued by the concept of knowledge graphs and data science over the web. ISI was one of the first organizations that pushed the DNS (domain name system) web protocol, so I decided to apply to ISI.

WHAT ISI VALUES RESONATE WITH YOU?

ISI values cross-team and multidisciplinary collaboration. Apart from my research interests, I also love artificial intelligence in my day-to-day life, and I make many different forms of art. You can find my work on Instagram @_baselart. I have always been interested in marrying different domains together, and ISI has helped me do this within my projects.

WHAT WERE YOUR PRIMARY RESEARCH FOCUSES?

Basel Shbita - My focus has been knowledge graphs which represent data in a semantic network where things have meaning. In my first year I was involved in the MINT project, building prediction systems for hydrology systems in South Sudan and Ethiopia, and scientifically representing them with knowledge graphs. I also competed in Amazon's Alexa Prize 2021, by building a knowledge graph and populating it with data from Reddit to fuel the Alexa bot. I moved on to geodata integration in the LinkedMaps project, where I tried to find a way to represent historical scanned map data from the United States Geological Survey (USGS). It's great to have had a chance to work with so many different groups and apply my love for knowledge integration.

WHAT'S THE MOST IMPACTFUL PROJECT YOU WORKED ON?

In my latest project, I analyzed geodata in maps to infer where critical minerals are and assess them for the USGS. There's a surge in demand for minerals such as copper, zinc, and nickel, which the world needs for developing green energy sources. Using a normal database to log these minerals took too long to show results, so we proposed using knowledge graphs which were more efficient. It was exciting to learn about multidimensional types of map data, as we weren't restricted to topographic data – we also geologically scanned layers of rocks.

WHAT'S ONE OF YOUR FAVORITE MEMORIES AT ISI?

I loved our retreat in Lake Arrowhead, which was very refreshing after COVID-19 as it was the first time I'd met colleagues I was working with in person. The retreat filled the intermediate social bridges we really needed.

WHAT ARE YOUR PLANS AFTER ISI?

I'm starting a job at IBM Research in San Jose. Two years ago, I published a paper with IBM on business data while interning with them. I used knowledge graphs to recommend business offerings to customers, and I'm heading back to that group. From the perspective of a scientist, working with real world data and industrial problems is very interesting. I would also like to work with ISI again. During my time at USC, I received the Outstanding Teaching Assistant award. This reaffirmed my love for teaching, and I might steer back into academia to teach at ISI in the future. ■

Myrl **Marmarelis** received his Ph.D. in Computer Science in August 2024, he was supervised by Greg Ver Steeg, Aram Galstyan, and Fred Morstatter. He was born and raised in Irvine, California, but lived in Greece briefly and attended elementary school there before returning to Palos Verdes, California for high school. He went to USC for his undergraduate degree, and his dad is a professor at USC.

WHY DID YOU CHOOSE A COMPUTER SCIENCE FIELD?

As a kid, I stumbled into programming because I wanted to build websites. I learned about HTML and C++ to make a game with 3D graphics. While studying computer science at USC, I came across some research by Roger Ghanem, and ended up publishing my first paper with him on optimizing the 3D printing process. I always liked machine learning (ML) too. During one high school science fair, I tried to build an exploratory neural network. One ML idea I enjoyed was training algorithms based on evolution theory, by pitting different models against each other and letting the "fitter" ones continue evolving.

WHY DID YOU CHOOSE ISI? WHAT MAKES IT UNIQUE?

When I was applying to Ph.D. programs, I got a call from Aram Galstyan, Director of the Artificial Intelligence Division at ISI at the time. He invited me to come visit ISI. After the visit, I got accepted and selected for a fellowship, which was a surprise! I also got introduced to Greg Ver Steeg and was absolutely blown away by his creative ideas on information theory. I like how ISI allows lab members to have a lot of autonomy. We also have an abundance of resources, much more than a typical research lab. This setup lets us collaborate across many different disciplines and share our expertise.

Mozhdeh **Gheini** received her Ph.D. in computer science in January 2025, she was supervised by Jonathan May. She was born and raised in Tehran, Iran. She did her undergraduate degree in computer software engineering in Iran and then came to the United States for graduate school. She joined ISI during the second year of her Master's degree, then began her Ph.D. here.

WHY DID YOU CHOOSE A COMPUTER SCIENCE FIELD?

We had a programming course back in high school and I really enjoyed it. I became interested in artificial intelligence and natural language processing (NLP). My first course during my Master's degree was an NLP course.

WHAT WERE YOUR PRIMARY RESEARCH FOCUSES AT ISI?

I mainly focused on NLP and efficient transfer learning methods, which is about adapting large language models to do specific tasks, and asking high-level questions like: 'Can we do it more smoothly with less data?' and 'How should we change the processes?'. I've always liked languages and NLP was one way for me to reconcile my technical background with my interest.

WHAT WERE YOUR PRIMARY RESEARCH FOCUSES?

I focused on a field in machine learning called causal inference, where we draw causal relations and conclusions based on data. I took predictive models and developed them to become more robust and accurate.

WHAT'S THE MOST IMPACTFUL PROJECT YOU WORKED ON?

In the field of causal inference, you often have a treatment variable and data, and you want to find the difference in outcomes between the treatment and control groups. I worked on a paper that investigated what happens when the treatment variable gets more complicated, and how we can nudge treatments to improve outcomes. One example of this is in the public health space, where we can find out what dietary factors can be changed so people get healthier. There's many confounding variables like exercise, pollution, and more that can affect health, so that's where causal inference can come in.

WHAT ADVICE WOULD YOU GIVE TO SOMEONE WHO IS CONSIDERING ISI FOR THEIR PH.D.?

Academia is an individual pursuit and your research is your brand. When reviewers are harsh or dismissive, know that this will push you to be a better researcher because you're actively trying things out.

WHAT ARE YOUR PLANS AFTER ISI?

I'll be doing a postdoc at Caltech. In the long term, I want to pursue causal inference and other topics by seeing how they fit into industry, so this might translate into a startup or a research lab of my own. I've also been consistently working with ISI's Abigail Horn on public health and dietary behavior research, so I hope to continue that line of research. ■

WHAT'S THE MOST IMPACTFUL PROJECT YOU'VE WORKED ON AT ISI?

Mozhdeh Gheini - My first official paper in my Ph.D. career was published in the 2021 Conference on Empirical Methods in Natural Language Processing (EMNLP). I was interested in transfer learning, which is about adapting an existing translation model to be able to translate other languages as well. I was curious if we needed to change all existing parameters while going from one language to another. My paper demonstrates that you can adapt models by only changing one part of the architecture called "cross-attention," which is the parameter that checks the source material during translation. The project showed that we don't need a lot of computational resources for translation, making it more accessible.

WHAT'S THE BIGGEST TAKEAWAY FROM YOUR TIME AT ISI?

Research is a patience game. It's like a domino effect: you can't reach the 100th domino without going through the first 99. You have to give everything the amount of time that it needs. Also, people often underestimate how far a simple hello can go. I had many discussions with people in the ISI corridors, which led to unexpected collaborations. The ISI community is strong and I will always feel like I am part of this family.

WHAT ARE YOUR PLANS AFTER ISI?

I want to start a research-oriented position in industry, preferably allowing me to continue doing NLP research. I want to experience how things are outside of academia, and observe how the nature of problems change. ■

George **Papadimitriou** received his Ph.D. in computer science in December 2023, he was supervised by Ewa Deelman. He was born and raised in Greece. He did his undergraduate degree in electrical and computer engineering in Greece and then moved to the United States for his Ph.D.

WHY DID YOU CHOOSE A COMPUTER SCIENCE FIELD?

My father was into computer engineering, and was involved in repair work. I decided to follow in his footsteps, but during undergrad, I noticed that I was more drawn towards computer science courses: anything to do with databases and high-performance computing was very interesting to me.

WHY DID YOU CHOOSE ISI? WHAT MAKES IT UNIQUE?

When I applied to ISI, I knew it was the place where DNS (domain name server) and internet research was born. I looked through ISI's advisors and found Ewa's work, which was a good fit for what I wanted to do.

WHAT WERE YOUR PRIMARY RESEARCH FOCUSES AT ISI?

I was interested in how the national cyberinfrastructure can be used to accelerate and accommodate experiments and simulations from other domains. I collaborated a lot with weather scientists and geoscientists, helping them run and deploy their applications in cloud computing. My research focused on how we can leverage the available infrastructure and introduce automation to deploy things on the fly. I also provided optimization on data movement and placement of tasks in the infrastructure. I chose this specific topic because I want to help scientists get the most out of the resources they have. I also enjoy cross-domain collaboration – for example, I knew nothing about weather sciences but I gradually learned what they do and what their needs were.

WHAT'S THE MOST IMPACTFUL PROJECT YOU'VE WORKED ON?

George Papadimitriou - I worked on a paper describing the infrastructure and deployment process we created for weather forecasting applications. It details how we can leverage cyberinfrastructure to optimize performance and automation. As the weather is always changing, there is a need to respond quickly during more critical periods like severe weather conditions. Having automation that is easy to execute has a direct impact on weather forecasters' day-to-day operations. It helps them identify locations in which there are dangerous conditions such as flash flooding, and lets them notify first responders rapidly as the process is fully automated, so they can help during adverse situations.

WHAT CHALLENGES DID YOU FACE DURING THE PROCESS OF RESEARCH?

I had to pick up and learn a lot of new fields and domains to understand why code works differently in certain scenarios. Also, during research, even if you want to explore many ideas, you have to prune them down to one that you can dive deeper into. This process can be frustrating, but I fortunately had a group to support me.

WHAT'S THE BIGGEST TAKEAWAY FROM YOUR TIME AT ISI?

I learned not to be afraid to reach out for help when I am facing a problem. Researchers should never be isolated when we're working. Since I did a lot of research rather than teaching when I was at ISI, I also realized my true passion lay in research and development rather than becoming a teacher at a university. My time at ISI helped me eliminate that future pathway.

WHAT ARE YOUR PLANS AFTER ISI?

I would love to work for a national lab in the United States, or as a research scientist in industry at a Big Tech company. If I end up working for a lab, I would collaborate with ISI as an external partner, to bring in new data that might be able to improve existing projects. ■

Binh Vu

Binh Vu received his Ph.D. in computer science in August 2024, and he was supervised by Craig Knoblock. He was born and raised in a small beach city in Vietnam. He earned his bachelor's degree in computer science at the Ho Chi Minh City University of Technology.

WHY DID YOU CHOOSE A COMPUTER SCIENCE FIELD?

My father was a mechanical engineer, so he often used his computer to design machines. My brother and I got to use computers at a very young age, and I tried my hand at programming in high school. I was considering business or economics afterwards, but I wanted to master technical skills earlier, so I decided on computer science.

WHY DID YOU CHOOSE ISI? WHAT MAKES IT UNIQUE?

When I was applying for my Ph.D., I realized that ISI's work aligned with my interests and I heard that the work environment at ISI was very flexible and collaborative. I'm lucky because I got so much support from Craig, and he helped me find projects related to my passions.

WHAT WERE YOUR PRIMARY RESEARCH FOCUSES?

Structured data is typically placed in tables and data sources, but it's difficult for machines to use this data because they're organized in different layouts. People often spend a lot of time extracting and normalizing data to formats they can use. Only a small fraction of time can be allocated to actually processing that data. My goal is to create semantic descriptions of these sources, so that data can be automatically extracted from them.

WHAT'S THE MOST IMPACTFUL PROJECT YOU'VE WORKED ON?

Binh Vu - My latest project is called CriticalMAAS, which is a critical mineral assessment using machine learning to extract data from maps and mineral reports. We came up with geospatial data that can be used to train ML models, allowing them to predict whether locations are likely to have minerals.

WHAT'S THE BIGGEST TAKEAWAY FROM YOUR TIME AT ISI?

One of the best pieces of advice was from Kevin Knight, who said, "Reading is when you're catching up, and writing is when you're producing knowledge." When doing research, you tend to overlook the fact that your research will become a valuable resource for people in the future. You should think critically and crystallize knowledge in an easily understandable manner. This concept has greatly influenced me and my work.

WHAT ARE YOUR PLANS AFTER ISI?

My long term goal is to form my own research team, working on important problems that can help society. ■

ASM Rizvi received his Ph.D. in computer science in June 2024, and he was supervised by John Heidemann. He was born and raised in Dhaka, Bangladesh. He did his undergraduate and master's studies in the Bangladesh University of Engineering and Technology, then worked with a US-based startup called Veriflow Systems where he became interested in networking and security related devices.

WHY DID YOU CHOOSE A COMPUTER SCIENCE FIELD?

I loved building new things with my older brother, who was also into engineering and coding. With computer science you can solve a lot of problems and pioneer technologies that have an impact.

WHY DID YOU CHOOSE ISI? WHAT MAKES IT UNIQUE?

At Veriflow Systems, I met a professor who recommended ISI as a good place to network and apply my skills. I visited ISI in 2017 and was amazed by the beautiful Marina Del Rey location and California weather. I also knew that ISI was unique for its contributions to internet research, as the first phase of DNS (domain name system) was designed at ISI and the "God of the Internet" Jon Postel used to be at ISI. With its robust tradition of research and the flexible work culture, ISI was an easy choice for me.

WHAT'S THE MOST IMPACTFUL PROJECT YOU'VE WORKED ON?

My research focused on network security and Internet measurement. I used different measurement techniques to improve network performance. For one of my projects, I built a system to mitigate denial of service attacks. During these attacks, servers are overwhelmed with malicious intrusions and since the server is overloaded, it can't serve legitimate clients anymore. At ISI we have a root server that was frequently susceptible to this type of attack. To deal with this, we built filtering and traffic distribution systems that shifted traffic from an overloaded server to another freer server. In terms of real world impact, this could be used to mitigate big server attacks that happen during globally important events.

WHAT ARE YOUR PLANS AFTER ISI?

I am joining Akamai Technologies as a senior site reliability engineer. When I first started working for Akamai as an intern, we collaborated with ISI and signed a legal contract which became part of my Ph.D. process. In the future, I hope to continue these collaborations. ■

Julie Jiang received her Ph.D. in Computer Science in May 2024, and she was supervised by Emilio Ferrara. She was born and raised in China, then she went to college at Tufts University, where she double majored in computer science and mathematics.

WHY DID YOU CHOOSE A COMPUTER SCIENCE FIELD?

When I went to Tufts about nine years ago, it was the coolest thing that everyone wanted to study, and Introduction to Computer Science was by far the most popular class. Half the freshman class was studying it, so I felt compelled to hop on the bandwagon. Then I realized that I actually liked it and switched majors.

WHY DID YOU CHOOSE ISI? WHAT MAKES ISI UNIQUE?

I visited ISI during the Viterbi Ph.D. visit day in 2019. It was a fun two-day event where I got to learn about some of ISI's research, and I met some amazing professors and current students that I really wanted to work with. Everyone was excited to talk about their work, share their experience, and discuss new research ideas. It was the kind of energy and vibe I was looking for in my Ph.D. program. Oh, and definitely Los Angeles. The beautiful ISI building in Marina del Rey was an easy sell.

WHAT WERE YOUR PRIMARY RESEARCH FOCUSES?

I researched online human behavior on social media. In this digital age, everyone's so connected, yet paradoxically we're also very disconnected because there's a lot of misinformation floating around. Your Internet self is probably not the most accurate representation of who you really are. I'm fascinated about why people do what they do and say what they say, and this interest in human behavior extends to every social media platform we interact on.

WHAT'S THE MOST IMPACTFUL PROJECT YOU'VE WORKED ON?

For one project, we worked on the idea that social approvals were a motivating factor for online hate speech. Using computational methods, we investigated empirically how hateful users behave on X, and came to the conclusion that social approvals (such as likes) may reinforce a hateful person's toxic behavior. This could have an immense impact on how we address online toxicity.

WHAT IMPLICATIONS DOES YOUR RESEARCH HAVE ON FUTURE DEVELOPMENTS/SOCIETY?

We found that social engagement can moderate or motivate hate speech. If you receive positive social engagement for your toxic posts, you're likely to become more hateful in the future. This brings a paradigm shift on how we can potentially moderate and curate online spaces. We could even stop hate speech before it happens because we know that social gratification motivates people.

WHAT IS THE BIGGEST TAKEAWAY FROM YOUR TIME AT ISI?

From collaborating with everyone at ISI, I learned how to conduct academic research. Now I'm well equipped both technically and scientifically to pursue the career in computer science that I want.

WHAT ARE YOUR PLANS AFTER ISI?

I plan on traveling a bit and then joining Meta as a research scientist working on high-impact projects. I also have many continuing projects with people at ISI that I would like to see to fruition! ■

BY COMBINING EXPERTISE IN CLIMATE SCIENCE, PALEOCLIMATOLOGY, AND AI, LINKEDEARTH IS CREATING NEW POSSIBILITIES FOR ANALYZING EARTH'S CLIMATE HISTORY, HELPING SCIENTISTS BETTER UNDERSTAND BOTH THE PAST AND, POTENTIALLY, THE FUTURE.
PHOTOGRAPH BY **FAINA GUREVICH/ISTOCK**

BRIDGING DISCIPLINES

The power of collaboration at ISI

BY JULIA COHEN

In today's research landscape, solving complex challenges requires interdisciplinary collaboration. At ISI, researchers from across USC's 23 schools unite to drive innovation. Adam Russell, AI division director at ISI, highlights the importance of integration in interdisciplinary work. "It's not just about combining expertise, effective interdisciplinary work means understanding different perspectives deeply enough to reshape the research questions and solutions," he said.

Building these teams starts with mutual understanding and respect. "You need to learn about the other disciplines to have efficient conversations and establish shared use cases," says Yolanda Gil, senior director for Major Strategic AI and Data Science Initiatives at ISI, who has received several awards for bridging AI and Earth Sciences. She carefully identifies collaborators who are open to connecting ideas across fields. "I train my team to be generalists," she says. "They should look at use cases and see general patterns across different scientific fields."

"It's not just about putting experts in the same room," adds Craig Knoblock, Keston executive director of ISI. "It's about creating a framework where their contributions can truly intersect to address complex problems." By doing so, ISI tackles challenges in healthcare access, climate science, information security, and more.

BRIDGING CLIMATE DATA GAPS: THE LINKEDEARTH PROJECT

Collaborating School: USC Dornsife College of Letters, Arts and Sciences, Department of Earth Sciences

Researchers: Deborah Khider, research scientist at ISI and paleoclimatologist; and Yolanda Gil, director of New Initiatives in AI and Data Science at the USC Viterbi School of Engineering, and senior director for Major Strategic AI and Data Science Initiatives at ISI; Julien Emile-Geay, a professor of Earth Sciences at USC Dornsife

LinkedEarth, co-led by Yolanda Gil and Deborah Khider from ISI and Julien Emile-Geay from the USC Dornsife Department of Earth Sciences, addresses a core challenge in climate science: making diverse paleoclimate data accessible and usable for research. Paleoclimate data comes in many forms, from ice cores to tree rings, but inconsistencies in how datasets are formatted and reported create barriers to analysis. "Each dataset is like its own island," explains Emile-Geay. "LinkedEarth is about building bridges between these islands so researchers can access and analyze data as a cohesive whole."

This collaboration began in 2016 with a National Science Foundation grant, following a workshop where Gil and Emile-Geay connected over their shared vision of leveraging AI to standardize paleoclimate data.

Emile-Geay provided the project's foundational questions, including how to align varied datasets to improve reconstructions like the well-known hockey stick graph, which visualizes temperature trends over the past two millennia. "Updating this graph with new data takes months," says Gil. "Julien was eager to speed up that process, and we had semantic technologies that could help scientists in different paleoclimate areas agree to consistent data representations."

The team standardized terms and reporting methods, creating a framework to represent climate data consistently across sub-disciplines.

"This isn't just about integrating data — it's about empowering collaboration," says Khider. "We wanted to make it easier for researchers to share and build on each other's work." Through workshops and training sessions, the LinkedEarth team has expanded its reach, empowering researchers to adopt its tools and contribute their own data.

EARLY GLAUCOMA DETECTION IN SIGHT: THE ATLAS INITIATIVE

Collaborators: Keck School of Medicine, USC Dworak-Peck School of Social Work, Los Angeles County Department of Health Services

Researchers: Carl Kesselman, director of the Informatics Systems Research Division at ISI, the William H. Keck chair of Engineering in the USC Viterbi School of Engineering; Benjamin Xu, associate professor of Ophthalmology at USC Keck School of Medicine; Shinyi Wu, associate professor of Social Work and Industrial & Systems Engineering; Lauren Daskivich, director of Eye Care Services, LAC DHS

The AI and Teleophthalmology in Los Angeles (ATLAS) Initiative, led by Carl Kesselman of ISI and Dr. Benjamin Xu of the Keck School of Medicine, tackles a critical global health issue: detecting glaucoma early enough to prevent blindness. Known as the "silent thief of sight," glaucoma often progresses unnoticed until vision is permanently damaged. Kesselman says, "We have developed new AI-ready datasets and tools that enhance the accuracy and reproducibility of our glaucoma detection algorithms." By using AI to analyze retinal images, the project seeks to detect early signs of optic nerve damage, transforming glaucoma care from reactive treatment to proactive prevention. "Our aim is to create a tool that identifies glaucoma at a stage when intervention can save sight," Xu explains.

A distinguishing feature of this initiative is its additional partnership with the Los Angeles County Department of Health Services and USC Dworak-Peck School of Social Work, which adds a holistic approach to ensure accessibility. "Early detection isn't just about medical precision — it's about creating a cost-effective solution that brings quality healthcare to underserved communities," says Shinyi Wu, an associate professor of Social Work. "Our approach minimizes long-term healthcare expenses by preventing advanced glaucoma, making our technological intervention both medically and economically impactful."

The tools developed are adaptable for use in healthcare settings such as primary care offices and community health centers, making them particularly impactful in low-resource environments. "Our goal is to create a solution that works where ophthalmologists may not be readily available," says Kesselman.

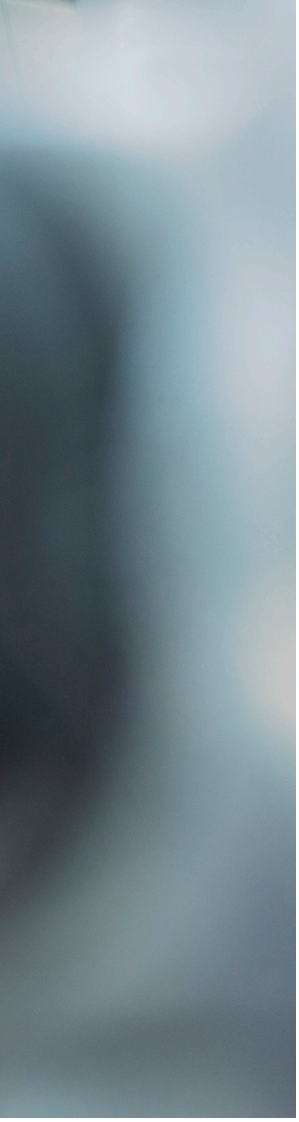
POLICIES FOR PROGRESS: THE MINERVA PROJECT

Collaborating School: USC Sol Price School of Public Policy

Researchers: Andrea Belz, professor of Practice in the USC Viterbi School of Engineering; Alexandra Graddy-Reed, associate professor at USC Price

The MINERVA Project (Management of INnovation, Entrepreneurial Research, and Venture Analysis) is a collaboration between ISI and the USC Price School of Public Policy that addresses funding trends for technology startups, examining how public and private funding decisions influence the development of transformative technologies. By understanding these factors, MINERVA informs policies that accelerate the transition of technologies from discovery to applications. "We look at the decision-making processes in both federal programs and private investments, and then we look at the consequences," explains Andrea Belz, a leader in entrepreneurship and innovation. "We uncover funding patterns that reveal problems on a national scale, and then translate these insights into actionable proposals. Our hope is to move beyond describing problems to formulating potential solutions."

To achieve this, MINERVA uses advanced data science and machine learning tools to analyze large datasets, such as grant



PHOTOGRAPH BY **ZORICA NASTASIC/ISTOCK**

applications and venture capital investments. These tools highlight patterns in the funding landscape and reveal ways to distribute resources for many national needs. "Together, we develop data-driven models and translate them into practical policy recommendations," says Graddy-Reed. "Our advanced data tools directly inform our proposals to make innovation funding more effective." MINERVA emphasizes impact, creating data tools for use by academic researchers and analysis for private investors to support the ecosystem. "At MINERVA, we want to inform the national conversation with rigorous analysis," says Belz.

TOWARD FAIRER JUSTICE: DETECTING BIAS IN LEGAL LANGUAGE

Collaborating School: USC Gould School of Law

Researchers: Jonathan May, principal scientist at ISI and research associate professor at USC Viterbi; and Jonathan Choi, professor of USC Law at Gould

The Detecting Bias in the Law project, led by Jonathan May at ISI, aims at identifying and mitigating biases in legal texts — biases that can shape judicial outcomes and disproportionately affect marginalized groups. The project uses advanced natural language processing models — May's specialty — to analyze large volumes of text from legal documents such as court opinions, statutes, and policy frameworks, to highlight patterns that may unintentionally reinforce stereotypes or discriminatory outcomes.

"We believe legal language may carry implicit or explicit societal biases that can influence outcomes," says May. "The goal is not just to detect where biases exist but to understand how they shape legal decisions and work toward fostering fairness." Jonathan Choi, a professor of Law at Gould, provides essential legal expertise, identifying areas where biases may occur. "We believe AI can uncover patterns that legal experts might miss," says Choi. "My role is to ensure those findings are accurate and meaningful within a legal framework."

The collaboration has also given May a new perspective on data analysis. "As computer scientists, we often focus on datasets without fully considering or knowing their provenance — the origins, transformations, and decisions that shape them," May explains. "Legal scholars think about data differently. A legal decision isn't the product of a single source; it's built from layers of rulings, interpretations, and contexts that can't be reduced to a single piece of data. I understood that intellectually, but working with Jonathan Choi has been fascinating in seeing how that plays out in practice."

QUANTUM SECURITY: ADVANCING QUANTUM COMMUNICATION

Collaborating School: USC Dornsife College of Letters, Arts and Sciences, Department of Physics and Astronomy

Researchers: Haley Weinstein, research scientist at ISI; Jonathan Habif, principal scientist at ISI; Todd Brun, professor of Electrical and Computer Engineering and Computer Science at Viterbi, and Physics and Astronomy at USC Dornsife

Haley Weinstein's work on quantum steganography — a method of hiding communication within what appears to be random noise — demonstrates a unique benefit that can emerge from interdisciplinary collaboration: bringing theory to life. This project, conducted with Todd Brun of Viterbi and Dornsife, and Bruno Avritzer, a Ph.D. student in physics at Dornsife, began with a theoretical protocol devised by Brun and Avritzer. "They developed a framework to make a laser signal indistinguishable from noise," Weinstein explains. "My advisor Jonathan Habif and I realized we could actually bring it to life using currently available technology." This achievement is considered rare in experimental quantum research.

The collaboration bridged two distinct worlds: theoretical physics and experimental engineering. "The theorists saw matrices; I saw voltages," Weinstein says. "Bridging that gap helped connect the theory to the experiment." By working together, Brun and Habif's groups proved that the protocol works in real-world conditions. Brun says, "It was remarkable to see the abstract problem that Bruno and I had worked on transformed into something that could actually be done in the lab with realistic technology, and even more exciting to see it produce real data." Habif adds, "It was inspiring to see two students with very different interests and types of training work closely together, learning from each other along the way. The result was two well-rounded young scientists and an exceptional new technology demonstration in the field of quantum information."

Currently, Weinstein is building a full transceiver to send data using the protocol, with potential applications in national security and data privacy. "This collaboration was possible because ISI is uniquely positioned at the intersection of academia and industry," Weinstein notes. "We have our finger on the pulse of real-world applications while still fostering the academic freedom to explore new ideas." ■

STUDENTS ATTEND STIMULATING STEM AT ISI IN JULY 2024
PHOTOGRAPHS BY **USC/ISI**

Empowering the *next generation* in STEM

BY STEPHANIE LEE

In summer 2024, 15-year-old Leo V., a rising junior at Orange Vista High School in Perris, California, embraced a rigorous routine. Each day he rose just before 8 a.m., ready to dive into a packed schedule of science and engineering courses. After 7 p.m., evenings found Leo back in the University of Southern California's dorms, not winding down, but pushing ahead with an online Algebra II course — a strategic step towards tackling pre-calculus in his junior year.

Afterwards, Leo finally put away his work and wound down in the student lounge, hanging out and watching movies with a new group of friends. These moments quickly became the highlight of his summer. "Meeting people from all over, hearing their stories, and being able to interact with them 24/7," Leo said, "that's been the most interesting part of this program."

A SAFE PLACE TO EXPLORE

Leo is one of 15 ambitious students attending Stimulating STEM, a free, intensive summer program hosted by ISI and supported by Capital One. Designed for disadvantaged high schoolers, the four-week program provides a safe and supportive environment to explore STEM fields alongside peers and mentors with similar backgrounds.

The environment not only encourages curiosity but also prepares students for future academic and professional settings. The program, which ran from June 23rd to July 19th, 2024, is free for participants.

"This was the best summer," said Stimulating STEM's program director Jamani King, who has run the program for the past three years. "The experience the students had is what we envisioned for Stimulating STEM."

Lisa Bland, the program's lead coordinator, added, "This year's group of students had a strong desire for knowledge and was excited to receive the information available to them. Their camaraderie with each other, the instructors, and staff was established early, which made the program a great success."

For four weeks, the high schoolers live on USC's campus, immersed in a multifaceted educational experience. Their days are filled with hands-on robotics workshops, intensive coding classes, and lectures on cutting-edge topics like AI and cybersecurity, taught by USC and ISI faculty members.

TINKERING, BUILDING, CODING

The robotics component of the program is a favorite for many students, including Leo, who was part of his middle school robotics team. Ever since third grade when his uncle first showed him a SpaceX launch on YouTube, Leo has aspired to become an aerospace engineer. "I'm fascinated by the rovers we have on Mars," he said. "My ultimate goal is to send something I've made into space."

Simone C., a rising junior at Immaculate Heart High School in Los Feliz, is also a builder by nature. During the academic year, she is hard at work doing light production for her high school's musical theater club. Robotics scratches the same itch to figure out how components come together. "I like the physical aspect of building things," she said.

Students also log weekly hours in the computer lab, tackling a semester's worth of college-level coding in just 10 sessions.

For Jessica A., a rising senior from Francisco Bravo Medical Magnet High School in Lincoln Heights, it's her first exposure to computer science. "It's really enjoyable," she said. "I had never done Python before this, but the way they're teaching this coding language makes it understandable, even though it's at a basic college level."

Jessica's newfound interest in coding reflects a deeper

appreciation for the opportunities the program offers. "A lot of people in my family haven't been to college and didn't get the experience that I'm getting," she said. "The fact that they gave me the opportunity to do this and expand my knowledge is very valuable to my education and future career goals."

INSPIRING PROJECT IDEAS

To inspire what is possible in STEM careers, the program also features lectures from ISI and USC faculty that illuminate diverse pathways in science and technology. In one session, Mayank Kejriwal, Principal Scientist at ISI, gave an overview of THOR, an AI for social good project designed to aid humanitarian efforts in regions with low-resource languages — those often endangered and lacking sufficient digital documentation and resources.

The lecture particularly resonated with Nayeli M., a rising senior at Anahuacalmecac International University Preparatory in El Sereno. Nayeli's school is an indigenous charter school in East Los Angeles, where students learn in three different languages: English, Spanish, and Nahuatl, a centuries-old language spoken by the Indigenous people of Mexico.

To Nayeli's surprise, Nahuatl — a language that has limited support from services like Google Translate — was part of this advanced research project, revealing how AI could be relevant to her community.

"Professor Mayank showed us how computing can apply to real-world problems, like with low-resource languages," Nayeli said. "I really like it when STEM integrates with social issues because I'm also very passionate about social advocacy and justice."

MEANINGFUL MENTORSHIP

Beyond academics, Stimulating STEM offers students a taste of college life and a chance to develop themselves through workshops, mentorship, and new friendships. "We want to make sure the students know how to govern their lives," King said. "Computer science and engineering are not easy. You have to understand time management and planning."

In workshops, students learn about navigating college life, from managing roommate relationships to dealing with perceived failures and maintaining personal wellness. Living together away from home, often for the first time, also provides a new experience where students learn to support and motivate each other. For students like Nayeli, whose graduating class has only 15 students, this social aspect can be eye-opening. "I'm talking to new people in this program. It's getting me outside my bubble," she said.

More challenging life topics are often addressed in one-on-one mentorship sessions, where students can discuss anything and everything with caring adults who are invested in their success.

"One of the best ways to help students with personal development is to allow them to hear your life story and share what steps you had to take to navigate into your career path, which is what many of our mentors and research leaders shared that inspired the students," said Bland, the program's lead coordinator. "Many of the students were able to see their school path and career choices more clearly after their sessions."

For Maria C., a rising senior at Bell High School in Bell, California, mentorship and personal development has been particularly valuable, building her confidence as she pursues her dream of becoming a nurse.

Maria's high school experience provides a stark contrast to the engaging environment of Stimulating STEM. She attends a Title 1 school — a public high school receiving additional federal funding due to its high enrollment of low-income students. According to Maria, it's a big school where many students "don't know how to act," making it challenging to get a quality education.

Despite these obstacles, Maria is leaving this summer with a boost. "I struggle a lot with myself. Nursing is very competitive, and I feel like I'm probably not going to get in," Maria said. "But my mentor, Ms. Jamani King, saw my passion and told me I could do it if I put my mind to it. She has helped me realize I have the potential to do more than I expect." ■


USC-ISI


EXIT
USC-ISI

Artist in (ISI) *residence*

BY JULIA COHEN

"The overlap between art and science isn't always obvious, but it's often where the most interesting ideas emerge," said Shantell Martin, the first Artist-in-Residence at ISI. Martin, a celebrated visual artist known for her bold black-and-white line drawings, is now based in ISI's Marina del Rey office. She brings a wealth of experience working at the intersection of art, technology, and research.

Recent notable work includes The Path: A Meditation of Lines, which turned Times Square's Broadway Plaza into a space for reflection from October 1 to November 20, 2024. The 160-foot mural between 47th and 48th Streets included a meditative walking path and guided audio meditations created by Martin. In September 2024, she created an immersive exhibition across public spaces at Rockefeller Center, transforming the iconic site into an artistic experience that invited visitors to engage with her flowing designs. In Los Angeles, her Intimate Whispers exhibition explored the dialogues we have with our inner selves, bringing her personal artistic themes to a broader audience.

Other projects include the 200-foot mural Dance Everyday in Buffalo, New York, which she drew in May 2018, celebrating the community's diversity; and an interactive installation in the Oculus at New York's World Trade Center that encouraged reflection with prompts like "Who Are You?" Not all of her work is on such a grand scale, however; in a collaboration with Mattel, Martin reimagined the iconic UNO deck. Her work has been exhibited at the Whitney Museum, Denver Art Museum, New Britain Museum of American Art, Museum of Contemporary African Diasporan Arts, MoMA, Albright-Knox Art Museum, Brooklyn Museum, and more.

"Shantell's residency demonstrates ISI's commitment to exploring new approaches to innovation and collaboration," said Craig Knoblock, the Keston executive director of ISI. "Her ability to distill complex ideas into visual narratives will challenge us to think differently and find creative solutions to the problems we tackle."

A WINDING PATH FROM LONDON TO ISI

Martin's journey to ISI has been as dynamic and non-linear as the bold lines that define her art. Born in London to a working-class family, she grew up navigating a mixed-race identity in a world that often felt contradictory. Drawing became her constant — a way to create clarity and connection.

Her artistic career formally began at Central Saint Martins College of Art and Design, where she studied graphic design and graduated with honors in 2003. After college, Martin moved to Japan, where her distinctive black-and-white line-drawing style took shape. Immersed in the underground art and music scenes, she performed live visual projections, honing her improvisational skills and refining the simplicity and flow that are hallmarks of her work today.

In 2009, Martin moved to New York City, where her art expanded into large-scale public projects, installations, and collaborations with major cultural institutions. Whether painting a mural, publishing a nine-foot-long coloring book, or collaborating with Kendrick Lamar, Martin's work may vary in size and medium, but consistently explores themes of identity, connection, and reflection. Now, her path has led her to ISI, where she brings a fresh artistic perspective to an environment rooted in innovation and exploration.

COLLABORATIONS WITH GLOBAL BRANDS

Throughout her career, Martin has collaborated with a variety of globally recognized brands, showcasing her ability to adapt her artistic vision to diverse contexts and work with a wide range of partners. With Nike, she designed custom sneakers that featured her iconic flowing lines, while her work with Puma resulted in a line of apparel blending her bold aesthetic with wearable fashion. Her partnership with the New York City Ballet led to visually striking backdrops for live performances, seamlessly integrating her art into a dynamic stage environment. Collaborations with Kendrick Lamar, Tiffany & Co., Vespa, and more highlight her ability to tailor her unique style to projects spanning fashion, music, luxury goods, and transportation.

Martin's success in collaborating across a broad spectrum of industries highlights her versatility and her ability to merge creative expression with diverse goals and audiences. This collaborative spirit aligns with ISI's mission, where her artistic perspective will intersect with the institute's cutting-edge research and technological expertise. Her residency promises to bring new ways of thinking to ISI's interdisciplinary environment, fostering innovative partnerships and creative breakthroughs.

COLLABORATIVE POTENTIAL AT ISI

At ISI, Martin hopes to draw inspiration from its researchers and their work, exploring creative possibilities in fields such as artificial intelligence, data visualization, and human-computer interaction. "There's something exciting about being in a space where the future is being shaped," she remarked. Her plans include bringing her experience with storytelling and spatial design into dialogue with the institute's technical expertise, potentially leading to new modes of visualizing complex ideas or creating interactive art-science experiences.

Martin will not only contribute her own artistic perspective but also work to foster creativity within the broader ISI community. She envisions hosting workshops on visual thinking, collaborative installations with ISI researchers, and conversations about how artistic methods can aid problem-solving in technical fields. "Art can be a tool to see things differently," she said. "It's about asking questions and finding meaning in places you might not have looked before." ■

Space passion, from France to Los Angeles

BY BERNICE CHAN

Space research, and the exploration of the unknown, has always been a pursuit that ties the world together. This concept was realized early on by David Barnhart, Director of USC's Space Engineering Research Center (SERC), a joint center between the Information Sciences Institute (ISI) and Department of Astronautical Engineering (ASTE). Deciding to help space research flourish internationally, Barnhart introduced SERC's work to Europe in an outreach project a few years ago. Today, SERC is known as a place that welcomes people around the world to engage in advanced space research together.

This year, SERC/ISI has invited three students from the French Air Force Academy (Ecole de l'Air et de l'Espace) for a four-month internship, working on developing prototypes of space-qualified robots. These robots improve space operations by facilitating processes such as debris removal, space platform maintenance, and lunar landing.

THE BIRTHPLACE OF GLOBAL COLLABORATION

"USC and SERC recognize that space is global, and we have embraced this concept by accepting students from all over the world as interns," explained Barnhart. "We have continued these collaborations for the past six years. For example, last summer, we invited German students to work on the LEAPFROG flight project. Past interns have also come from Japan, Mexico, Sweden and India, and we've supported Italian graduate students in the past as well."

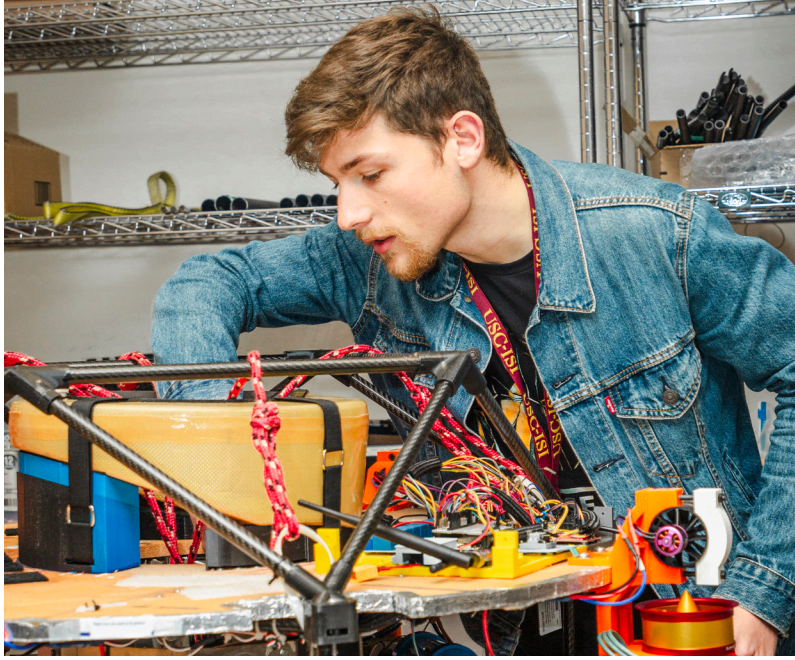
International interns at SERC/ISI contribute to fundamental research projects that have real-life applications. This focus on hands-on research instead of theoretical pursuits, according to Barnhart, is one key feature that draws interns to SERC. Through this process, they gain valuable insights while working in teams with USC students.

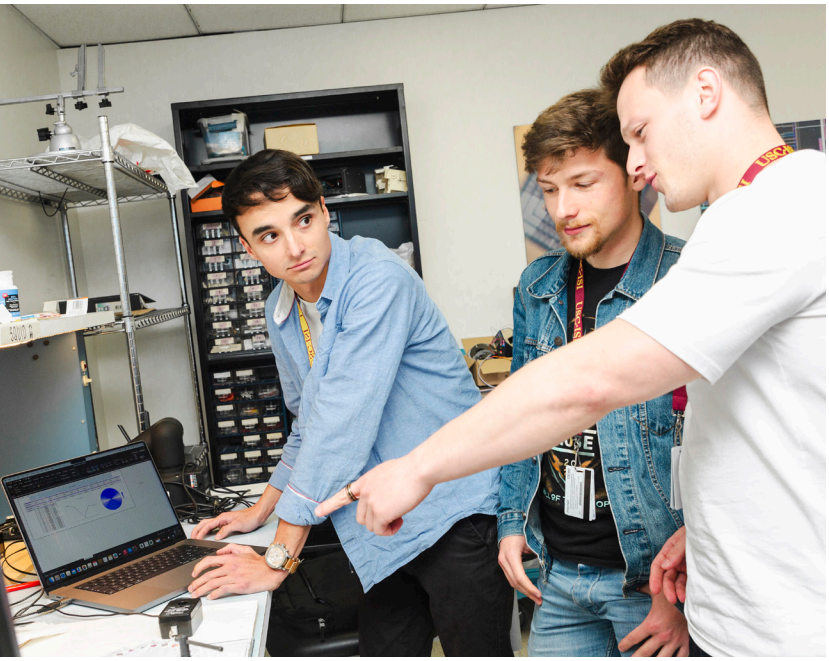
"In France, there are usually only two or three people studying existing theories," Mickaël, one of the French interns, recalled. "However, at SERC our projects are far from done – we have to create our own solutions and conduct real investigations with a larger team. This is part of the American experience that we want to bring back."

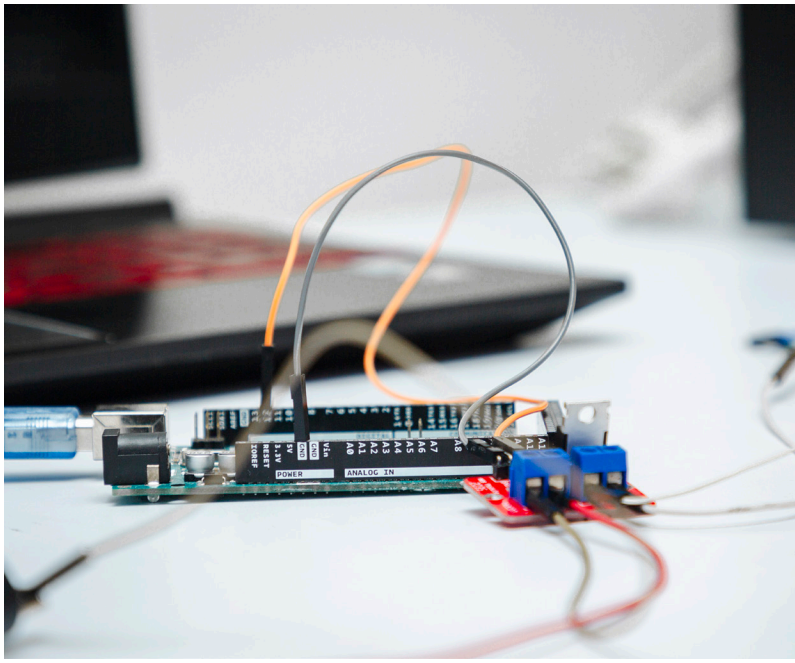
ACCELERATING SPACE EXPLORATION

At SERC, interns have the flexibility to choose projects that they are passionate about and will benefit from the most. "I chose the LEAPFROG lunar lander project because it uses space technologies and hardware that I was familiar with in France," Thibault, another French intern, said. "I applied what I've learned to create a navigation system for the LEAPFROG module, so that it can land accurately." The lunar lander requires both GPS and accelerometers to ensure that its location can be precisely and consistently updated. This is because there are no satellite signals – and therefore no GPS – when the robot arrives on the moon.

Thibault is working to secure multiple accelerometers that perform the same task on the LEAPFROG module. If one fails or breaks down, the others can take over. "Using my theoretical knowledge from France to improve a real world module in the US is very rewarding," remarked Thibault.







MICKAËL, THIBAULT AND ALEXANDRE, STUDENTS AT THE FRENCH AIR FORCE ACADEMY, SPENT FOUR MONTHS IN USC/ISI'S SPACE LAB. PHOTOGRAPHS BY **ANGEL ITUA**

DRIVING RESULTS, GAINING EXPERIENCE

Seeing tangible results from their research efforts is also something that drives interns towards the projects they are working on. "I wanted to work on the SQUID project because I knew that I would be able to craft and build things around it," Alexandre, the third French intern, said. SQUID aims to create an informatic model to optimize the force of Gecko adhesive grips. The Gecko grips are used on the REACCH debris gripper robot, and Alexandre is trying to maximize their capacity to grab old satellites and debris in space.

The interns are conscious of the impact their work has on future space operations. "My project STARFISH has three focuses: reducing human risk, allowing maintenance on space objects, and making significant progress in the new and relevant field of soft robotics," Mickaël explained. He hopes that his work on STARFISH, a soft crawling robot used to inspect and repair space stations, will help the robot displace objects more efficiently.

FOSTERING CULTURAL SYNERGY

SERC interns bring new approaches to problem-solving, creating an environment suited for cross-cultural collaboration. The French interns aim to bring what they have learned back home after completing their time at SERC. "We're used to passing or failing tests on our first try back in France," Mickaël explained. "At SERC we're allowed, or even expected, to test and fail. Realizing that we can learn from our failures and try again with new methods has been very valuable." Alexandre added "I've also been able to interact with, and learn from, a lot of other foreign students at SERC who bring different ways of thinking to solve problems."

SERC also benefits greatly from these internships. "International interns add to SERC's rich culture of innovation," Barnhart said. "Our research center is like a rich tapestry that grows with every new member. The space innovation we come up with is enhanced with international participation." ■

AI/nsiders

ISI's podcast

BY NINA MOOTHEDATH

Over the last year, AI division director Adam Russell has hosted the AI/nsiders podcast, speaking with ISIers about their lives, their work, and their views about the future of AI.

"The power of the AI division and ISI truly comes from its people collectively," Russell said. "I think the podcast helps highlight how everyone has ideas and insights that are worth paying attention to, and often those from the folks who aren't steeped in the traditional career paths are most valuable."

ISIers come from all over the world, including Iran, Italy, Brazil and China. Ph.D. student Casandra Rusti remembers moving to the US from Romania at 12 years old, while Ph.D. student Justin Cho recalls growing up across a number of countries.

"Prior to Hong Kong, I was in the United Arab Emirates…and before that, I was in Korea. Before that, there were a bunch of different countries like Austria, Russia, and Norway," said Cho. "I would consider myself a global citizen."

In addition to their different geographical backgrounds, guests on the show discussed the unique interests that brought them to ISI. For Research Scientist Deborah Khider, it was a passion for scuba diving that brought her to the field of oceanography. For Research Assistant Professor Abigail Horn, a motivation to solve problems in food systems and chronic diseases led to her exploring AI as a tool.

"If you care about a problem, you will learn what's necessary along the way to help you get where you want to be, get you out of bed in the morning, and drive you forward," said Horn.

For several ISIers, science fiction was an influence in making the decision to pursue computer science, changing the way they imagined the future of AI and how it could help humanity. Star Trek in particular was a popular source of

inspiration for a better world, including for Research Associate Professor Mayank Kejirwal.

"Star Trek: Voyager was my first exposure to what we would now call AI," said Kejirwal. "I want the Star Trek world where there's no war and poverty, and I do believe eventually we will get there."

Although ISIers held high hopes about the future of AI, many also expressed concerns about issues related to accessibility. Research Associate Professor Jonathan May discussed how he worries tools being built are not being made equally available, while postdoc Emmanuel Johnson discussed how including different perspectives are important to building better AI systems.

"When we start building AI to interact with people, we make certain assumptions. If we're saying AI is helpful, what does helpful mean? When we say AI is caring, what does that mean?" said Johnson.

Another source of concern ISIers mentioned were the misconceptions people have about AI. Ph.D. student Rebecca Dorn described how complicated terminology can make AI seem more unapproachable than it actually is, while Research Assistant Professor Fred Morstatter discussed the dangers of believing an algorithm can't be unfair.

"That's something that we really have to address in public discourse. These things learn from past data, and past data has all of the errors that have been made throughout history. If we're not careful, we're just going to propagate them," said Morstatter.

Despite their caution, many ISIers also expressed confidence in humanity's ability to address AI issues. Ph.D. student Mozhdeh Geini explained that, while creating regulations will be challenging, she hopes others don't give up on what could be incredibly helpful tools. Research Associate Professor Kristina Lerman shared that she's an optimist about humanity's ability to overcome challenges created by technology and the future in general.

"I wish I could tell my younger self that the world is going to be even more miraculous than I imagined," said Lerman. "There are so many things to be excited about and hopeful for."

To make this better future a reality, ISIers hope to solve a wide number of problems with their work. Research Engineer Joel Mathews explained how his work aims to make translation more accessible, and Ph.D. student Ashwin Shreyas described how he hopes his research might address the issue of online misconstruction.

"If I do have a certain impact in this field, it would be an increase in content accuracy" said Shreyas, "How it's going to be done is a bigger mystery at this point, but it's a mystery that I want to try and solve."

Along with their research, many ISIers teach at the USC Viterbi School of Engineering.

Research Engineer Gleb Satyukov shared how much he enjoys the 'aha' moment where he sees concepts click for his students, and Jonathan May explained that working with students is simply the best part of his day.

"Having student meetings is just absolutely glorious. To watch them learn and to learn from them, because they know a whole lot more about the latest and greatest than I do, it's just incredible," said May.

Outside of work, ISIers use their skills in a number of unique ways, including pursuing cricket, poetry, costume design, dance, photography and improv comedy. Some felt these experiences have shaped the way they approach AI, including Ph.D. student Alex Spangher, who described how a project working on fixing a boat has grounded him.

"When I look at the electrical system on the boat and the way it's falling apart and rusted and sparks are coming out, I have to get into the physical really quickly. We make this mistake thinking about AI as some kind of metaphysical cloud thing, but at the end of the day, they are engineering systems as well," said Spangher.

With their diverse experiences, guests on the podcast shared their advice to those looking to join the AI field, and to those who are already in it. Ph.D. student Julie Jiang advised her peers to pursue learning about their interests even after college.

In November 2024, Russell launched the spin-off podcast ISI/nsiders, where he interviews ISIers across all divisions. He expands his quest to the other disciplines researched at ISI. Networking, cybersecurity, computing, microelectronics, quantum, space, ISI scientists have a lot to say about the state of their fields, their research topics, and how AI fits into them.

"If you consider the different types of backgrounds we've already come to meet in a single division at ISI – the AI Division – I'm looking forward to meeting even more folks who are further outside my area of AI," Russell said. "I'm hoping to ask even more curveball questions to get a sense of who people are, not just what they do." ■

Cloudwalkers

ISI and the Inventors of the Future

BY JULIA COHEN

In 1972, ISI was created to solve the world's most difficult technical problems. *Cloudwalkers: ISI and the Inventors of the Future*, written and directed by Emmy award-winning filmmaker Daniel Druhora, covers the breadth of ISI's storied history.

The feature-length documentary spans ISI's founding, catalyzed by the Pentagon Papers and the increased government focus on computer networking; to its role designing, developing and running the Internet, which led to one of the greatest explosions of information in human history; to the astonishing and varied work being done by ISI researchers in recent years through today. The documentary blends historical insights with tales of technological triumph that have reshaped our world.

Featuring commentary from Internet co-inventor Vint Cerf, ISI pioneer Bob Balzer, and current faculty, researchers, and staff, *Cloudwalkers* is filled with personal anecdotes and never-before-heard tales of ISI. Paul Mockapetris, a former ISI researcher, Internet Hall of Famer, and inventor of the Domain Name System (DNS), narrates, guiding viewers through some of ISI's most impressive and long-lasting contributions to the Internet, including his own DNS invention.

As the Internet grew, so did the need to ensure its safety. ISI has been at the forefront of cybersecurity research, ensuring the

safety and integrity of the Internet it helped create. *Cloudwalkers* delves into ISI's role in advancing cybersecurity, featuring insights from world-class experts from both inside and outside the walls of ISI. Viewers are shown how cybersecurity has evolved from the early Internet to today, and how ISI has played a critical role in that advancement.

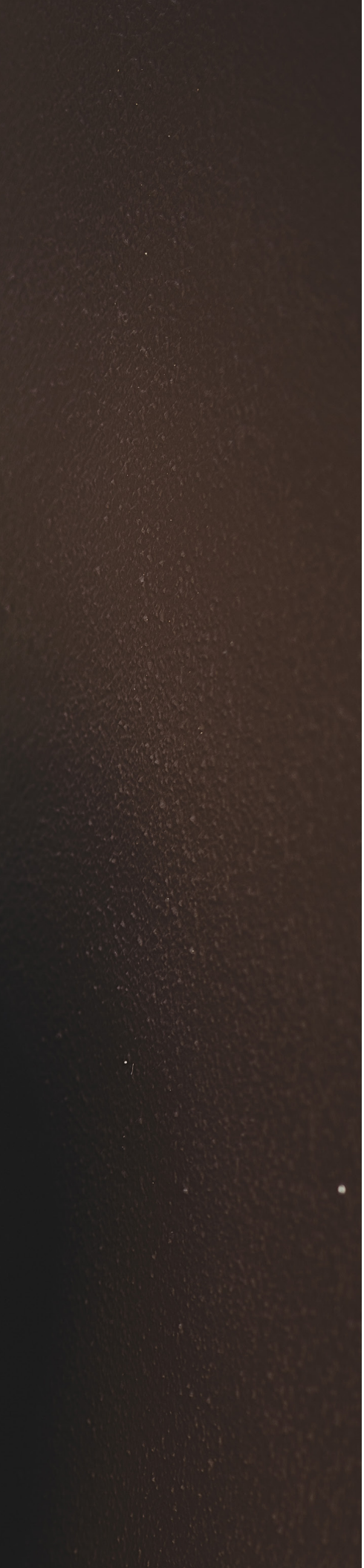
Finally, the documentary offers a glimpse into recent ISI projects: studying memory formation using zebrafish data, fighting human trafficking, mitigating AI bias, and applying machine learning to professional sports. These examples showcase what's possible when smart, creative people tackle the world's toughest challenges.

More than a retrospective, *Cloudwalkers* celebrates ISI's enduring legacy of innovation. Stream now on Amazon Prime to discover how ISI's groundbreaking innovations continue to shape the technology powering our world. ■

Watch it

NOW

PHOTOGRAPH BY **KATIE RAIN PHOTOGRAPHY**



And the *DNS* was born

BY PAUL MOCKAPETRIS

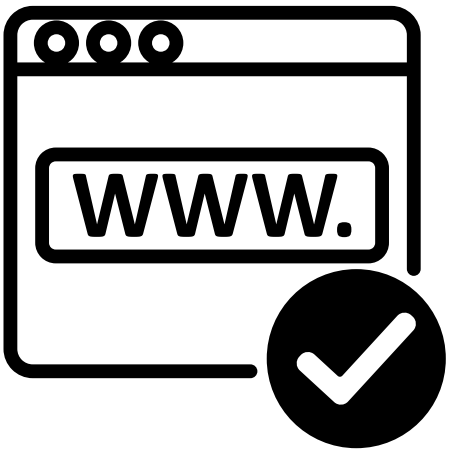
While working at ISI in the 1980s, Paul Mockapetris invented a technology that remains fundamental to the Internet: the DNS, or Domain Name System. The DNS acts like the Internet's directory, allowing people to access websites using human-readable domain names (www.isi.edu) rather than computer-readable IP addresses (141.193.213.20).

The magic of the DNS is that it's completely open and scalable. Each organization gets to manage their own piece of the internet's naming system on their own servers, and anyone's computer anywhere in the world can access this information. Today, the system is used by billions of people — or their phones and computers — and consists of millions of servers and tens of billions of names. Paul Mockapetris tells the story of how the DNS was born.

THE QUESTION

I joined ISI in 1978 as a graduate student from UC Irvine. It was a magical place: the computers were plentiful and ISI was working on many of the core issues of network research. My team was made up of about 20 or so people supervised by the late Jon Postel, who later earned the nickname "god of the Internet" for his role in creating the Internet Assigned Numbers Authority (IANA).

At the time, the network research community was gearing up for the transition from the ARPAnet, the first operational computer network, to the IP/TCP-based Internet, which we have today. Almost any aspect of network design was up for rethinking. One day, Jon walked into my office and asked whether I'd like to work on the domain naming problem. It's hard to overstate how attractive that opportunity was.



ARPANET: A PRECURSOR

In the early days, SRI, a Silicon Valley-based research institute, managed the ARPAnet. Their operation used a file called hosts.txt, which listed all the computers on the network as well as their associated addresses. To change or add a computer to the network, you had to call SRI during their business hours. They would assign you a network address number and add it to their master host table. Periodically, people would get updated copies of the file. This sort of worked like a phone book — with the exception that new versions of the phone book got published more often.

The drawback of this scheme was that the cost went up as the number of machines on the network grew. As a solution, the research community began to talk about a domain naming system, but there was no real blueprint on how to build it. This is the problem I set out to solve.

MAKING THE DNS WORK

The first step was to design a system that could be implemented. I came up with two proposals for the DNS, published as RFCs 882 and 883 in 1981. One documented the system's overall principles; the other, implementation guidance.

Several aspects of the design were controversial. While the work was meant to be a system for matching names to addresses, it was really a distributed database capable of adding a virtually limitless number of other data types. Previously, reliability in network protocols was accomplished by retransmitting requests until they were acknowledged; the DNS changed that by requiring multiple servers for any particular data, with the requester moving on to the next server if a request went unanswered. This new approach made the older, more complicated connection methods unnecessary.

The next step was to actually code the server. This was my doing, supported by Ruth Brungardt and later Steve Hotz, who did supporting utilities and test suites. In 1984, we launched the first DNS server on the 11th floor of ISI, and then set up other name servers in places like SRI.

To get people to join the DNS, ISI folk gave many tutorials and helped others implement the system for various computer systems. Perhaps the most famous implementation was BIND, or the Berkeley Internet Name Domain — a software package designed at UC Berkeley that allowed computers to participate in the DNS. Progress was enabled by a rock solid service on the PDP-10s, which were popular computers at the time. Later, when BIND was included in Berkeley's free version of the UNIX operating system, it helped spread the DNS system widely through academia and beyond.

THE END OF THE BEGINNING

By 1986, operating systems and machines were being built that relied solely on DNS, abandoning the old host tables entirely. That's when I knew the system had truly become "production." Commercialization was happening, and the DNS started walking the tightrope without a net.

Because of its success, that same year ARPA decided that the DNS was no longer breakthrough research. That meant that funding was going away, and I had to find something else to do. ARPA ended up offering me a job as a program manager — a rewarding opportunity in public service that exposed me to many new research frontiers. Meanwhile, Jon Postel and ISI continued to operate one of the expanding root server constellations, and administered the allocation of domains and Internet numbers.

DNS TODAY

Today, ISI still manages a root server, and does some DNS research. In late 2024, I listened to UCLA researchers that are still adding new DNS applications to solve new problems. Some see the over 100 DNS additions documented in RFCs as bloat, and there are certainly failures there as well as successes.

Looking back, I never anticipated how domain names would become the equivalent of stock market certificates or real estate deeds, representing billions in value. The system has also become a battlefield for cybersecurity. At ThreatSTOP, my current company, we track domain names associated with cybercriminals and state actors.

I think of the original DNS work as the foundation and first few floors of a very tall structure. Dan Lynch, ISI's former computer center director, used to say that I was the only person he knew that invented a billion dollar industry, but neither I nor ISI cashed in. Still, the DNS remains a crucial building block of the Internet today, and that's worth something. ■

2024 ANNUAL REPORT

USC *Information Sciences Institute*

USC Viterbi

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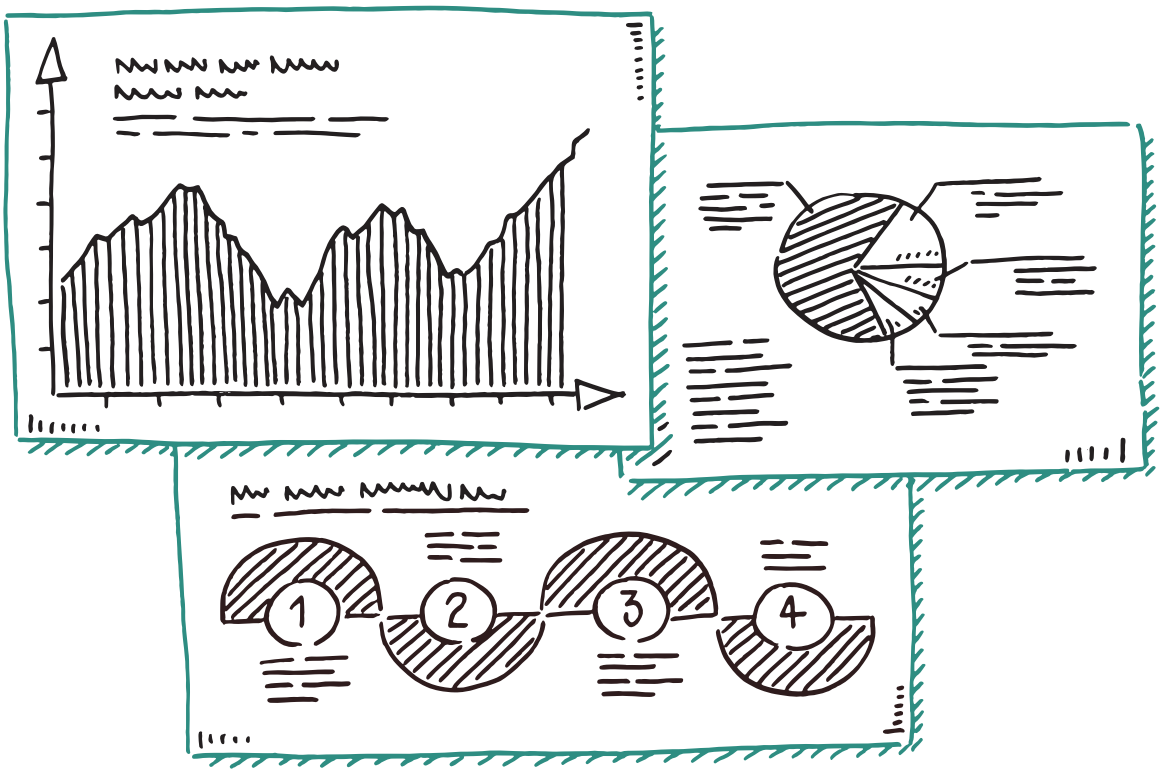


OUR DIVISIONS

"Leading ISI in the wake of change"

TERRY BENZEL, MBA
ASSOCIATE DIRECTOR OF ISI

Leadership at ISI extends beyond guiding world-class research; it's about navigating shifts in the research landscape while building an adaptive and successful business model. In order to do the great work we do at ISI, we depend on reliable funding sources.

The accelerated pace of technology and innovation is having an effect on the world of research funding. Private-sector investments in areas like AI and natural language processing now rival those of traditional government R&D agencies. This shift challenges soft money institutes like ISI to rethink strategies, becoming not just responsive to funding opportunities but proactive in shaping them.

To succeed, ISI's leadership prioritizes building relationships with new sponsors, including foundations and industry partners, while actively surfacing new ideas to our customers early in the ideation process. We also encourage our researchers to carve out more time for ideation — developing bold, forward-thinking concepts that can shape research agendas. By becoming more proactive, ISI can thrive in this new funding landscape.

Leading ISI into a new R&D environment relies on new types of collaboration and a shared understanding: every success at ISI is a collective win. While we value innovation and deep principal investigator research, we are increasingly a living, breathing organization where every person — from researchers to administrators — can contribute their expertise to important initiatives in a multidisciplinary team environment. At ISI, we call this culture "all in for the win."

The story of SPHERE, a multi-million-dollar cybersecurity research infrastructure initiative, exemplifies this ethos. ISI faced a tight deadline to complete the full proposal—a challenge intensified when SPHERE's lead principal investigator gave birth to her fourth child during the process.

The institute rallied as a true team: administrative staff built detailed work breakdown schedules tables, researchers from unrelated projects lent their expertise, and colleagues from across ISI stepped in to refine, organize, and polish the proposal. The result was an $18 million success that showcased the power of "all in for the win" teamwork.

Ultimately, ISI is not simply adapting to change; it is leading through it. By fostering a proactive mindset, strengthening relationships, and reimagining how we work, ISI's leadership is positioning the institute for continued growth and impact. Change is never easy, but at ISI, it is embraced as an opportunity to innovate and evolve. ■

LEADERSHIP

CRAIG KNOBLOCK, PH.D.
Keston Executive Director

TERRY BENZEL, MA, MBA
Associate Director ISI

STEPHEN CRAGO, PH.D.
Associate Director ISI, CA DREAMS Director

YOLANDA GIL, PH.D.
Viterbi Director for Major Strategic AI and Data Science Initiatives

ADAM RUSSELL, PH.D.
Artificial Intelligence Division Director

DAVID BALENSON, MS
Networking and Cybersecurity Interim Division Director

MATTHEW FRENCH, M.ENG
Computational Systems and Technology Division Director

CARL KESSELMAN, PH.D.
Informatics Systems Research Division Director

ELIZABETH BOSCHEE, BS
ISI Boston Director, Artificial Intelligence Division Associate Director

JOHN WROCLAWSKI, MSEE
Senior Director for Strategic Initiatives

DEREK MIKURIYA, MBA
Director, Human Resources

ISI BY THE NUMBERS

STAFF, FACULTY, AND STUDENTS

345+

Postdocs	Ph.D. Students	Summer Interns	Faculty
2	101	5	22

STAFF AND FACULTY DEGREES	
Bachelor's	48
Master's	46
MBA	8
Ph.D.	70

Astronautical engineering

Biomedical sciences

Civil and environmental engineering

Communications

Computer science

Electrical and computer engineering

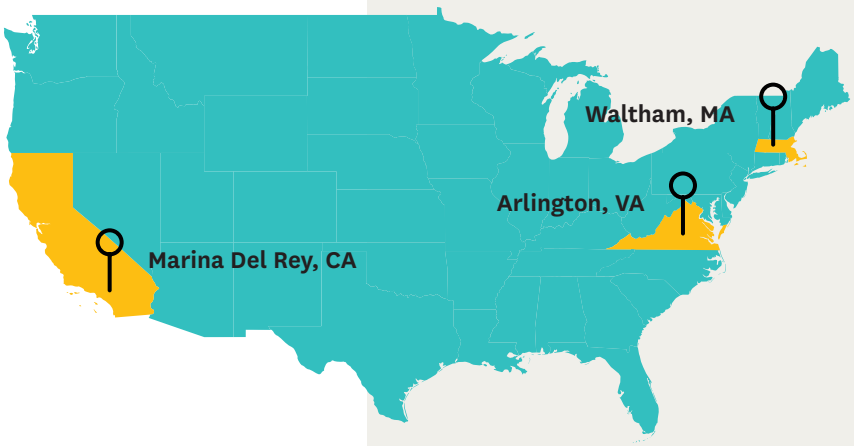
Physics and astronomy

Population and public health sciences

Preventive medicine

Spatial sciences

ISI LOCATIONS



TOTAL OFFICE SPACE

160,196 SQ FT

QUANTUM COMPUTERS

ONE

2024 NEW RESEARCH GRANTS

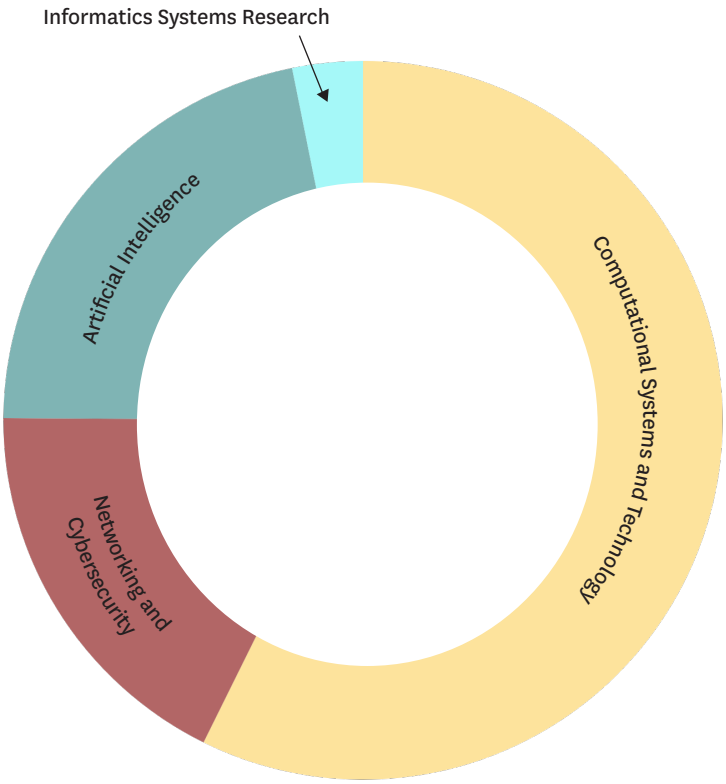
45

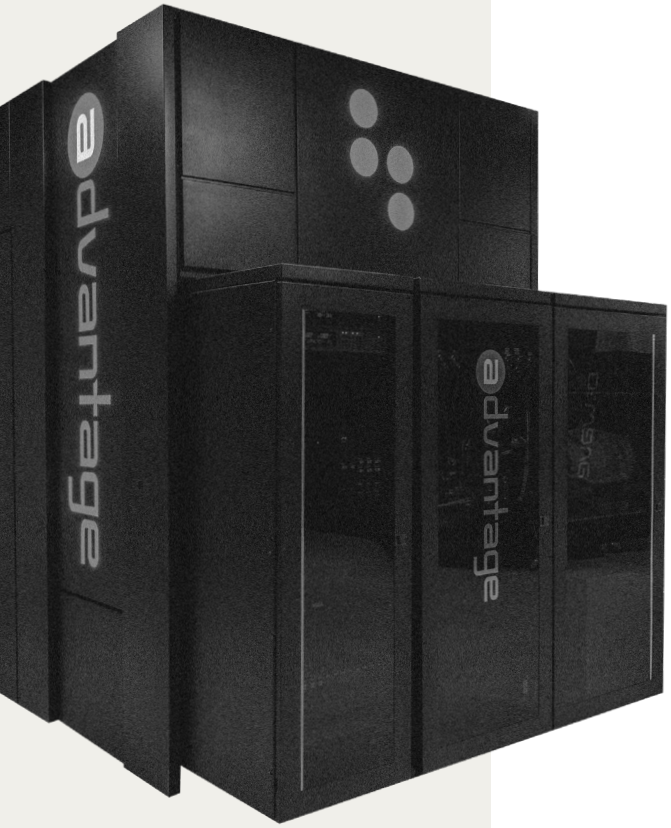
2024 RESEARCH EXPENDITURES

$80M

2024 SEMINARS

54





Artificial Intelligence

- Machine learning and data science
- Natural language processing
- Knowledge graphs
- Scientific data analysis and discovery
- Multi-modal understanding
- Common sense and reasoning
- Computational social science
- AI fairness

Networking and Cybersecurity

- Cyber experimentation research, methods, and infrastructure
- Network measurement, analysis, and defenses
- Security for wireless networks
- Cyber-physical systems and autonomy
- Networking consensus algorithms
- Understanding communication for human-focused agents
- Modeling human behavior for cybersecurity

Computational Systems and Technology

- Secure, robust, and trusted electronics
- Heterogeneous and cloud computing
- High performance computing architectures and software
- Science automation technologies
- Quantum information science
- Materials, devices, circuits, and architectures for advanced microelectronics, photonics, and magnetics; hardware architectures for artificial inteligence and sensors
- Space engineering research

Informatics Systems Research

- Informatics cyberinfrasctructures
- Medical informatics

ISI TIMELINE

1970

1972
- ISI founded by Keith Uncapher
- ARPANET interface

1974
- ARPANET Voice Over IP

1977
- ARPANET Addressing and Request for Comments

1979
- Packet Radio Terminal Concept

1980

1981
- MOSIS Semiconductor Implementation Service

1983
- Internet Domain Name System
- Digital Phone Communications

1985
- Packet Video

1988
- Rhetorical Structure Theory

1990

1992
- Internet Society

1993
- Online Payments

1997
- FASTXchange Spin-off
- ISI Arlington

1998
- ICANN Spin-off

1999
- USC Institute for Creative Technologies Spin-off

2000

- Internet2 Collaboration
- Practical Rhetorical Theory

2003

- DETERLab Cybersecurity Testbed

2008

- Reconfigurable Robots

2009

- SoCal Seismic Hazards Map

2010

- Nano-Satellite

2012

- USC-Lockheed Martin Quantum Computing Center

2014

- Sports Data Analytics

2015

- Human Trafficking Search Tool
- Social Media Bot Detection

2017

- ISI Boston

2019

- MOSIS Alliance with Intel Corporation

2022

- ISI 50th anniversary
- ISI Arlington 25th anniversary

2023

- USC announces Frontiers of Computing
- ISI leads Southern California hub for microelectronics
- SPHERE testbed to replace DETERLab

2000

2010

2020

Artificial *Intelligence*

ADAM RUSSELL
DIVISION DIRECTOR
ELIZABETH BOSCHEE
ASSOCIATE DIVISION DIRECTOR

The Artificial Intelligence Division (AID) at ISI is one of the world's largest AI research groups, with over 160 research faculty, staff and graduate students. Most researchers hold graduate degrees in computer science or related disciplines, and many hold research faculty appointments at the USC Viterbi School of Engineering. The division conducts fundamental and applied research, and – as can be seen from our website - AID researchers actively work across a broad range of technical spaces and disciplines. We believe this assortment of people, technologies and topics is critical for helping us contribute to three areas of growing societal and strategic importance: first, building "superteams" with AI to achieve previously impossible things, whether those are superteams for scientific breakthroughs or superteams for better decision-making. Second, bolstering democracy with AI by building capabilities to make sure that AI ultimately proves to be a positive asset for all of us. Third, being prepared - with AI - by creating capabilities to help society better anticipate, respond to, and ultimately mitigate emerging risks from everything from potential pandemics to even socio-technical risks from AI itself.

ILLUSTRATION BY **HENDRA SU**

>AI

In 2025, our strategic vision centers on a fundamental principle: ensuring humanity remains "greater than AI" (>AI). While artificial intelligence continues its remarkable advancement, our mission is to harness and direct these capabilities in service of human flourishing, not as an end in itself.

This >AI framework drives every aspect of our operations. AID researchers and our partners are continuing to focus on "AI Now": that is, using and developing current generation AI that can have real-world impact today - accelerating scientific discovery, improving healthcare outcomes, analyzing complex data to inform decision making, enhancing our capabilities to forecast what's coming, and more - while ensuring that AI systems enhance rather than replace human cooperation and coordination. That is, the way we solve problems with AI can help us remain >AI.

And in such a dynamic landscape as today's AI, we are mindful of the advances yet to come and the step-functions we are supporting - tomorrow's AI (or "AI Next") that we'll need to address future problems. This requires pioneering new techniques on the frontier of AI research to tackle currently intractable challenges: creating AI that actually reasons, understands us and our

world, and can act in ways that are consistent with our most important collective values. Hence, our research teams are exploring metacognitive AI architectures that demonstrate deeper understanding of human contexts and needs; looking to build AI systems that promote virtuous cycles, where humans and AI can make each other better through breakthrough advances in AI security, alignment, and robustness; and developing approaches to evaluating AI systems not just for technical performance, but for their tangible impact on team dynamics, institutional effectiveness, and human wellbeing. We are mindful that, in no small irony, will we need better AI if we are ourselves to remain >AI.

Finally, this focus of being >AI also depends on better understanding what AI is doing for, and to us, in order to help us harness AI as it is deployed into the real world. This focus on being able to characterize "AI In The Wild" - AI that has been released into our communities, systems, and institutions - is about helping all of us to realize AI's immense promise while mitigating its considerable pitfalls, many of which we are only just beginning to understand. Ensuring our systems and communities are >AI means building standards and meaningful evaluations for pre-deployment testing and continuous monitoring of AI systems in real-world applications, developing innovative impact measurement frameworks, and looking to characterize how AI In The Wild affects everything from individual health outcomes to organizational collaboration patterns.

By maintaining this holistic perspective, we ensure that our world-class talent and technological capabilities serve their highest purpose: ensuring humanity's wisdom, flourishing, and collective intelligence are greater than, and greater because of, artificial intelligence itself.

While the path into the future is uncertain, one thing is clear - the only way around is through. And even as we figure out how to chart our way through an environment of unpredictable funding, technological advance, and geopolitical competition, we will never lose sight of our vision: to build AI that amplifies rather than diminishes human potential. This means developing systems that are inherently collaborative, that strengthen rather than strain our institutions, and that expand rather than contract the sphere of human agency. Through rigorous testing, thoughtful deployment, and continuous evaluation, we're creating AI that serves as a powerful tool for human advancement while ensuring that our future - which depends on human wisdom, judgment, and wellbeing - remains >AI.

MACHINE LEARNING AND DATA SCIENCE
Developing efficient algorithms to analyze data from various application areas, including biomedical sciences, computational social science, and cybersecurity.

NATURAL LANGUAGE PROCESSING
Low resource machine translation, multilingual representation learning, transfer learning, dialogue, decision-making, question answering, summarization, ontologies, information retrieval, extracting critical information about world events from foreign language sources.

KNOWLEDGE GRAPHS
Using AI and machine learning techniques to construct and exploit large-scale knowledge bases and to induce taxonomies from data.

SCIENTIFIC DATA ANALYSIS AND DISCOVERY
Interactive knowledge capture, intelligent user interfaces, semantic workflows, provenance, large-scale data integration, analysis of biomedical data.

MULTI-MODAL UNDERSTANDING
Image and video understanding for deepfake detection and identification and multimedia analysis, face recognition, biometric anti-spoofing, learning "common sense" knowledge from text, video, images, and audio, learning to automatically discover the structure of complex events from multilingual multimedia data.

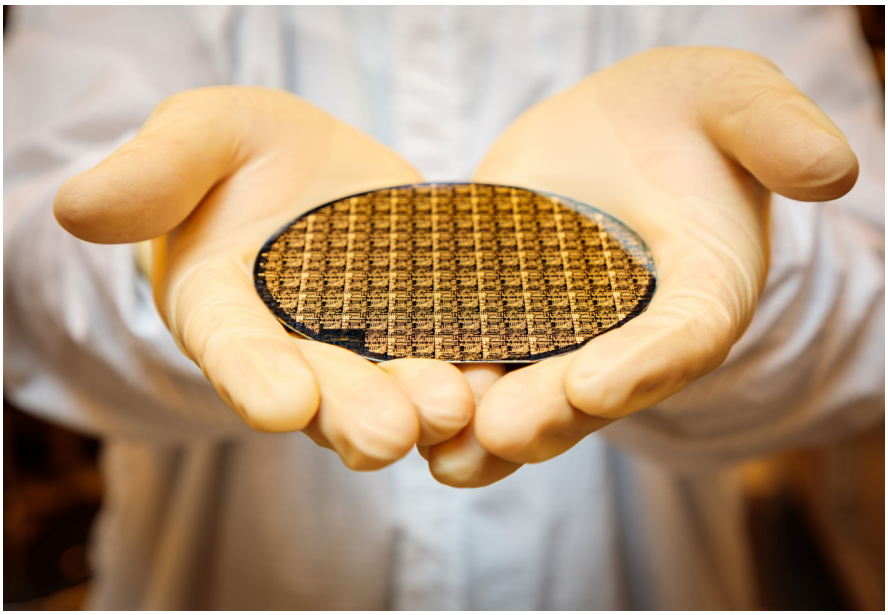
COMMON SENSE AND REASONING
Building cognitively inspired computational paradigms for evaluating common sense AI, human-centric dialog agents, game-theoretic simulators.

COMPUTATIONAL SOCIAL SCIENCE
Structure detection and pattern matching in unusually complex systems with hidden information, large-scale contextualized social media analysis, detecting and responding to social engineering attacks.

AI SECURITY - Measuring AI robustness against adversarial attacks and unintended behaviors, identifying AI vulnerabilities, and characterizing (and seeking to mitigate) risks that emerge as humans and AI systems interact.

Computational Systems & Technology

MATTHEW FRENCH
DIVISION DIRECTOR



The CS&T division addresses all aspects of computing systems — from atoms and circuits, to computing architectures and software. The division continues to grow, welcoming the Space Engineering Research Center (SERC) into the fold and connecting SERC's spacecraft research with CS&T's existing thrusts in edge processing, embedded systems, and microelectronics to comprehensively address the space domain. The California Defense Ready Electronics and Microdevices Superhub (DREAMS) is at full-throttle and MOSIS 2.0 has already released new offerings as a result.

The USC Quantum Computing Center (QCC) pursues research spanning quantum computing, communication and sensing research, and the Secure and Robust Electronics Center (SURE) researches assured microelectronics and privacy preserving computation. New forms of computing such as computational physics, in-pixel computing, optical computing, reconfigurable computing, edge computing and 2.5D and 3D heterogeneous integration of application specific hardware are a major thrust. These innovations are unleashed through research in system software, compilers, runtime frameworks and science automation technologies.

• At the Laboratory for Quantum-Limited Information (QLIlab), researchers explore how to build the most sensitive communications and sensing devices when a signal is imprinted on only a fraction of a photon — the fundamental quantum particle of light.

• The Science Automation Technologies Group (SATG) explores the interplay between automation and management of scientific workflows including resource provisioning and data management. The group leads the Pegasus Workflow Management software and conducts research in job scheduling, resource provisioning in distributed systems, workflow performance modeling, provenance capture, and use of edge and cloud platforms for science.

• The Heterogeneous Systems Group (HSG) spans supercomputing to the computational edge. The group's expertise includes the development of performance-portable compilers and runtime systems, fault tolerance for next-generation space processors and artificial intelligence on resource-constrained devices.

• At the Application Specific Intelligent Computing Lab (ASIC) researchers apply "alternate state variables" such as electrons, photons, phonons and magnetic spins to deliver next-generation hardware fabrics using novel monolithic and heterogeneous device integration for artificial intelligence, smart sensors, smart and secure manufacturing and quantum information.

FOCUS AREAS

- SOFTWARE
- HARDWARE ARCHITECTURE
- DEVICES
- MATERIALS & MANUFACTURING

CA DREAMS ENTERS YEAR 2

In its second year of operation, CA DREAMS, led by ISI, will focus on two major projects to advance semiconductor technologies in the United States. One focuses on developing a next-generation semiconductor material known as gallium nitride. The other aims to create advanced prototypes for faster, more reliable wireless networks. Northrop Grumman, a defense technology contractor and CA DREAMS hub partner, will oversee the projects' execution.

The Department of Defense (DoD) is supporting the projects with $31.9 million in funding, announced in September 2024. CA DREAMS — which stands for the California Defense Ready Electronics and Microdevices Superhub — is one of eight regional innovation hubs established under the DoD Microelectronics (ME) Commons Program, which is funded by the CHIPS and Science Act of 2022. The hub brings together 16 funded partners across the Southern California region, including research universities, Department of Defense semiconductor fabrication facilities, and numerous small businesses. Together, they will unite their resources and technologies to enhance how microelectronics move from laboratory to production.

The hub also aims to reinvent MOSIS, a service that transformed semiconductor innovationin the 1980s. With MOSIS 2.0 ISI will not only continues offering MPW services but also expands to a second core focus: prototyping compound semiconductors. These emerging materials outperform traditional silicon-based chips, making them critical for next-generation technologies.

The new capability is made possible by CA DREAMS' network of partners, including seven university nanofabrication labs and three defense industrial base (DIB) fabrication facilities across Southern California.

Networking & *Cybersecurity*

DAVID BALENSON
INTERIM DIVISION DIRECTOR

The prevalence and interdependence of cybersecurity, networking, and systems that impact our lives informs the research and development agenda of the Networking and Cybersecurity Division. Networking is the backbone of the interconnected world, and cybersecurity is its guardian. The 50+ researchers, faculty, Ph.D. students, and student workers in the division focus on cyber experimentation, network measurement, Internet operations, research datasets, security for wireless networks, and trustworthy health systems. "Our division stands at the forefront of securing the digital and physical worlds. By innovating in areas like experimental research infrastructures, AI-driven cybersecurity, and quantum-augmented networking, we enable resilient systems that empower a safer, interconnected future," says David Balenson, division director. "From space systems to autonomous vehicles, we address today's challenges while shaping the networks of tomorrow." The division aims to redefine the future of networking and cybersecurity.

CYBER EXPERIMENTATION RESEARCH, METHODS, AND INFRASTRUCTURE

Catalyzing a robust ecosystem of experimental infrastructure, capabilities, and communities by creating models, frameworks, testbeds, tools, and approaches to enhance the science of cyber experimentation. Make the experiments rigorous, reusable, and repeatable.

NETWORK MEASUREMENT, ANALYSIS, AND DEFENSES

Developing novel Internet measurement techniques, tools, and data; applying formal methods and temporal logic for operational identification of attack dependencies and descriptions of traffic behaviors.

DNS ROOT SERVER

Supporting Internet operations through our b.root-servers.net critical infrastructure, which provides Domain Name Service for the DNS root zone, handling 5 billion requests a day as a public service to the Internet and to support DNS and naming research.

Looking into the Division's Future Research Agenda

In the coming year the division will extend its long history of R&D to explore fundamental questions around redefining networking and cybersecurity, and to expand into new research areaa.

NETWORKING is core to all aspects of research and daily operations across many fields. As information science rapidly accelerates, we will explore research challenges in the community ranging from decentralizing the internet, to fully encrypted networking, to formally verifiable networks.

SPACE SYSTEMS are facing an increasing threat landscape focused on all aspects of Earth-to-space, space-to-space, and space-to-Earth. These threats include jamming, spoofing, and cyberattack. We are engaged with industry, government, and research labs to explore the application of zero-trust architectures, network operating systems for satellites, DevSecOps, hardening of interfaces, and cybersecurity testbeds for space.

SECURING VEHICLES is a critical need. A big challenge is the lack of data available to support research. ISI and its collaborators are building data collection devices and developing a portal to make needed datasets and associated tools available to support the computer science and engineering community pursuing research in automotive and autonomous vehicle security and privacy.

THE SPHERE RESEARCH INFRASTRUCTURE is a major, four-year research infrastructure construction project that will transform and democratize access to cybersecurity and privacy experimental infrastructure. This infrastructure will offer access to a variety of hardware, software, and other resources, connected by user-configurable network substrate, and protected by a set of flexible security policies. It will offer six user portals for different populations of users, support reproducible research via infrastructure services and community engagement activities, and seek to increase access to underrepresented communities in computing.

OPERATIONAL MISSION SECURITY will explore the use of AI to enhance operations and intelligence data analysis, with a focus on securing critical missions through effective information sharing and improved performance of human analysts in high-pressure environments. Additionally, we will investigate the development of resilient systems — spanning hardware, software, and cyber-physical domains — that are secure, resistant to attacks, and capable of recovering effectively from incidents.

QUANTUM-AUGMENTED NETWORKING is exploring the use of quantum technologies to enhance classical data networks' properties and capabilities, such as security, resilience to new attacks, situational awareness and observability, and stealth. We are developing a quantum-augmented network interface card (QNIC) that can be commercially built and deployed in the near future, as well as a software framework to facilitate wide-scale deployment of quantum-augmented networking services now and in the future.

NETWORKING AND SECURITY DATASETS

Enabling research with new, rich, and diverse datasets via a framework for collaborative, community-driven data enrichment and labeling. Making data available while ensuring privacy and enabling flexible computation; and generating diverse datasets, including with malicious traffic, to enable research into better defenses.

SECURITY FOR WIRELESS NETWORKS

Improving the security of wireless networks, including 5G and next generation mobile networks, through novel network embedding techniques, constraints validation, and protection of information; applying machine learning to assist identification of applications based on their network traffic. Applying advanced network mapping capabilities.

CYBER-PHYSICAL SYSTEMS AND AUTONOMY

Studying the semantics of cyber-physical systems (e.g., space, energy, medical) to understand how software will interact with higher-level, human-understandable physical models, operate in mission-critical zero-trust environments, and interoperate with legacy systems.

TRUSTWORTHY HEALTH SYSTEMS

Developing an evaluation methodology for medical chatbots that reflects patient needs, by understanding patient usage and chatbot response patterns and then developing techniques to measure a chatbot's overall accuracy and completeness as well as the calibration of the confidence and other factors that impact usability.

Informatics Systems Research

CARL KESSELMAN
DIVISION DIRECTOR

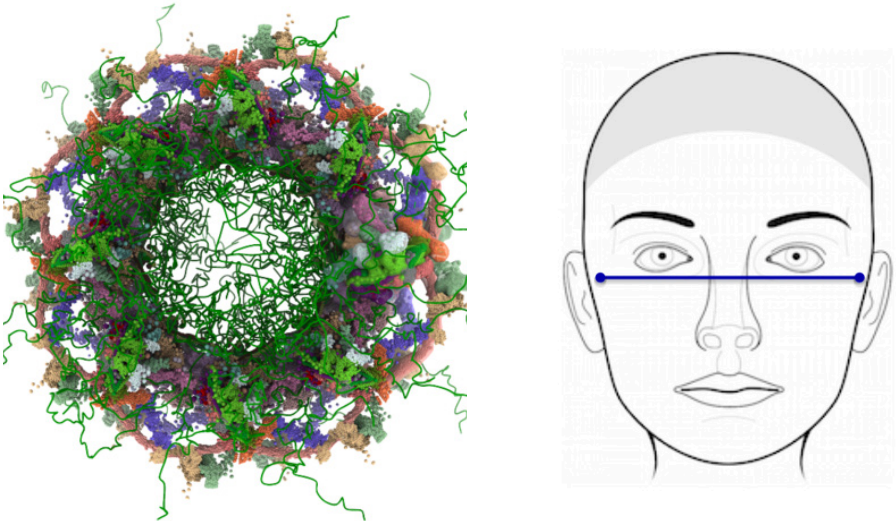
The research agenda of ISI's Informatics Systems Research Division focuses on creating new types of sociotechnical systems that enable and accelerate discovery in domains of high societal impact. The Informatics Systems Research Division takes a holistic, systems-oriented approach, working in areas ranging from basic network service architectures, data management abstractions, computer security, and user-interface design to domain-specific algorithms. The division specializes in highly collaborative, user-driven research in the context of high-impact domain science.

In earlier work, the Informatics Systems Research Division developed grid computing infrastructures to support the creation and operation of "virtual organizations" as a foundation for scientific collaboration and discovery. This work, which focused on understanding methods for sharing computing and storage, played a role in three Nobel prizes:

THE EARTH SYSTEM GRID FEDERATION contributed to the large-scale climate models for the International Panel on Climate Change.
2007 NOBEL PEACE PRIZE

THE DATA ANALYSIS FOR DISCOVERING THE HIGGS BOSON was performed on a global grid infrastructure, the Worldwide LHC Computing Grid.
2013 NOBEL PRIZE IN PHYSICS

THE DISCOVERY OF GRAVITATIONAL WAVES took place using the LIGO Data Grid and the Open Science Grid.
2017 NOBEL PRIZE IN PHYSICS



INTEGRATIVE STRUCTURE OF A MACROMOLECULAR ASSEMBLY ARCHIVED IN THE PDB SYSTEM. FACEBASE CAPTURE.

COLLABORATIVE PROJECTS

Researchers work with ISI's artificial intelligence, networking, and distributed systems experts and with two of USC's nationally ranked Viterbi School of Engineering departments: Computer Science and the Daniel J. Epstein Department of Industrial and Systems Engineering.

The division participates in collaborative projects with faculty, from basic science to clinical use cases in molecular biology, basic neuroscience, neuroimaging, stem cell research, and craniofacial dysmorphia. ISRD collaborates with the Research Collaboratory for Structural Bioinformatics Protein Data Bank (RCSB PDB) to enhance the PDB archive. The PDB archive is recognized as the single global repository of experimental three-dimensional structures of proteins, nucleic acids, and complex macromolecular assemblies, and is a rare treasure trove of high-quality, curated, and standardized scientific data. The PDB is widely credited with enabling the 2024 Nobel Prize in chemistry by facilitating the creation of AI tools that solved a fifty year old challenge in structural biology. Building on our PDB work, we collaborate with partners at Rutgers University and University of Basel to create the next generation ModelArchive data repository for complementary in silico models of macromolecular structures. Together, these collaborations lay the foundation for solving the next great challenge in biology — understanding the molecular anatomy of the cell.

ISRD plays a central role in multiple international consortiums. Examples include FaceBase, a NIDCR-funded project that houses comprehensive data in support of advancing research into craniofacial development and malformation, and NIDCD-funded temporal bone database, which supports research related to deafness and communication disorders.

Centers & *Labs*

Through collaborations with government agencies, industry partners, and academic colleagues and students, ISI Centers and Labs cover a diverse range of disciplines. Utilizing rigorous design, modeling, and prototyping techniques, our broad capabilities facilitate the development of novel approaches to address issues in the natural and digital world. ISI Centers and Labs are at the forefront of innovation, enabling trailblazing research to advance science, and usher in a more robust and secure technological age.

AI Research for Health

YOLANDA GIL DIRECTOR

JOSE-LUIS AMBITE, YANG CHAI, DAVID CONTI, ABIGAIL HORN, CARL KESSELMAN CO-DIRECTORS

The center on AI Research for Health was created to nurture collaborations between researchers in AI and those in the health sciences. Focus areas include: Data management, Precision health, Machine learning for health, Telehealth, Knowledge discovery and data analytics. The center sponsored the First Joint Workshop on AI Research for Health, co-hosted by the USC Norris Comprehensive Cancer Center, to identify and pursue potential avenues at USC for leveraging innovations in AI to impact health and make new discoveries in critical, challenging health problems. The center received seed funding for four years from a generous donor. ISI matched the first year of funding to award two projects: "Quantum Transfer Learning for Precise Dose Prediction of Stereotactic Radiosurgery and Body Radiotherapy" and "Artificial Intelligence Solutions to Address an Emerging Crisis in Glaucoma Care".

Analysis Of Network Traffic: The Ant Lab

JOHN HEIDEMANN FOUNDER

The goal of the Analysis of Network Traffic Lab (ANT Lab) is to improve the Internet by discovering new ways to understand network topology, traffic, security, use, and abuse. ANT was originally founded in 2000. The group's research is led by multiple principal investigators in ISI's Networking and Cybersecurity Division in collaboration with principal investigators from the University of Memphis and Columbia University. The lab carries out Internet measurement with active and passive data collection and big data analysis of network data. ANT has received support from the Department of Homeland Security, the National Science Foundation, DARPA, and from Cisco, Verisign, Northrup Grumman, Amazon, and a Michael Keston Exploratory Research Award.

CI Compass: An NSF Cyberinfrastructure Center Of Excellence For Navigating The Major Facilities Data Lifecycle

EWA DEELMAN DIRECTOR

CI Compass provides expertise and active support to cyberinfrastructure practitioners at NSF Major Facilities, such as the Laser Gravitational Wave Observatory (LIGO), the National Ecological Observatory Network (NEON), and the Regional Class Research Vessel (RCRV). These facilities develop and operate unique scientific instruments, data, and computational capabilities for scientists, engineers, students, and the public. CI Compass provides advice, design choices, and proof of concepts related to the Major Facilities Data Lifecycle. This multi-university collaboration, which includes researchers from Indiana University, RENCI, the University of Notre Dame, Texas Tech, and the University of Utah, contributes knowledge and expertise to enhance the NSF cyberinfrastructure ecosystem.

Center on Knowledge Graphs

JAY PUJARA DIRECTOR

The Center on Knowledge Graphs creates new approaches for amplifying artificial intelligence using structured knowledge. The group combines expertise in artificial intelligence, machine learning, the Semantic Web, natural language processing, databases, information retrieval, geospatial analysis, business, social sciences, and data science. The center has built tools and knowledge graphs to address challenging, real-world problems such as reducing global food insecurity, fighting human trafficking, assessing medical and clinical data, fostering pharmacological discovery, and ensuring scientific reproducibility.

Center for Cyber Defense Technology Experimental Research

TERRY BENZEL CO-DIRECTOR

JELENA MIRKOVIC CO-DIRECTOR

The center advances cyber experimentation research, methods, and infrastructure to foster a robust ecosystem of cyber capabilities, infrastructure, and communities. Researchers develop models, frameworks, testbeds, tools, and methodologies to enhance the science of cyber experimentation, ensuring experiments are rigorous, reusable, and reproducible. For 20 years, the center operated the DeterLab Cybersecurity Experimentation Testbed, a public resource serving over 1,000 researchers from 46 countries and educating more than 20,000 students in cybersecurity. It also developed Merge, a modern, open-source framework for testbed control and management, designed for large-scale, high-fidelity, and resilient experimentation. Currently, the center is building the Security and Privacy Heterogeneous Environment for Reproducible Experimentation (SPHERE) under NSF's mid-scale research infrastructure program. SPHERE will provide at-scale, realistic, and reproducible cybersecurity and privacy experimentation across diverse hardware. Researchers and educational users of DeterLab are already working with a beta version of SPHERE — general compute nodes running Merge software.

USC - Quantum Computing Center

DANIEL LIDAR SCIENTIFIC & TECHNICAL DIRECTOR

FEDERICO SPEDALIERI OPERATIONAL DIRECTOR

The Quantum Computing Center (QCC) is housed at ISI. Faculty, researchers, and students perform basic and applied research into noisy, intermediate-scale quantum (NISQ) computing devices and collaborate with researchers around the world. The Quantum Computing Center was the first organization outside D-Wave Systems to house and operate its own D-Wave quantum computer, and it has conducted pioneering research on four different generations of these early NISQ processors Quantum computing potentially offers orders-of-magnitude gains in speed and memory, as well as greater security, for some computing problems. Applications include "big data" analysis, classification, optimization, and machine learning.

STEEL: Security Research Lab

JELENA MIRKOVIC DIRECTOR

Founded in 2012, STEEL researchers, Ph.D. and master's students conduct cutting-edge research in cybersecurity and testbed experimentation. The lab focuses in network-based cyber attacks, human aspects of cybersecurity, embedded cybersecurity, and binary analysis. STEEL also contributes to improving security through cyber testbed experimentation, including work in making experimentation more rigorous, more accessible, and reliably reproducible.

Science Automation Technologies: SciTech

EWA DEELMAN DIRECTOR

The Science Automation Technologies group (SciTech) conducts research and provides technologies that empower the scientific community to efficiently conduct complex computations on the national, campus, and industrial cyberinfrastructure. By raising the level of abstraction for computation specification (abstract scientific workflow) and by designing workflow management systems, scientists are able to focus on their research questions rather than the details of the cyberinfrastructure.

The group develops open-source tools that provide the computational foundations enabling scientists to seamlessly run their experiments and analyses in local and distributed resources.

The group concentrates on these research areas:

- Workflow management systems for science
- Machine learning for science
- Enhancing national
- Cyberinfrastructure
- Modeling and simulation of distributed computing systems

Space Engineering Research Center

DAVID BARNHART DIRECTOR

The Space Engineering Research Center (SERC) is dedicated to disruptive space engineering, research, and education for the second-generation workforce — including hands-on training to build, test, and fly spacecraft and satellites. SERC hosts high school, community college, undergrad, graduate, and Ph.D. students from the U.S. and worldwide.

SERC is a longstanding joint venture between ISI and the USC Department of Astronautical Engineering.

SERC seeks to challenge traditional methods of space R&D, manufacturing, and exploration with approaches that dramatically reduce costs, enable novel capabilities, and support the creation of space-to-space services and interactions.

Secure and Robust Electronics Center

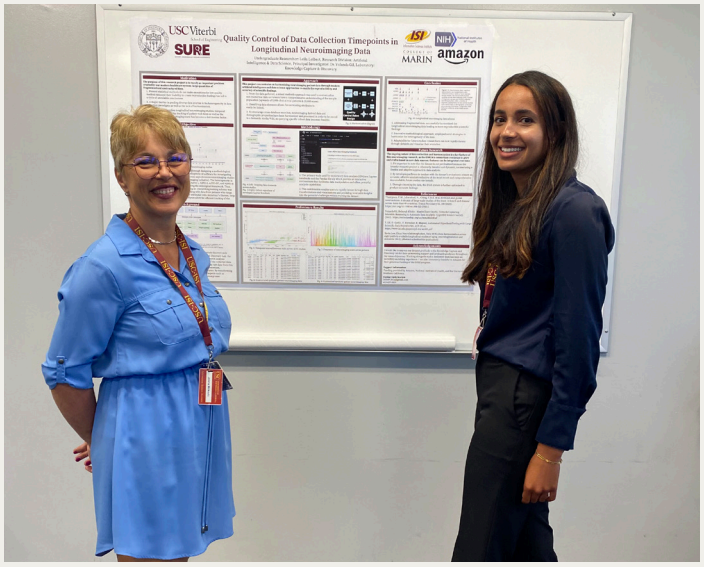
MATTHEW FRENCH DIRECTOR

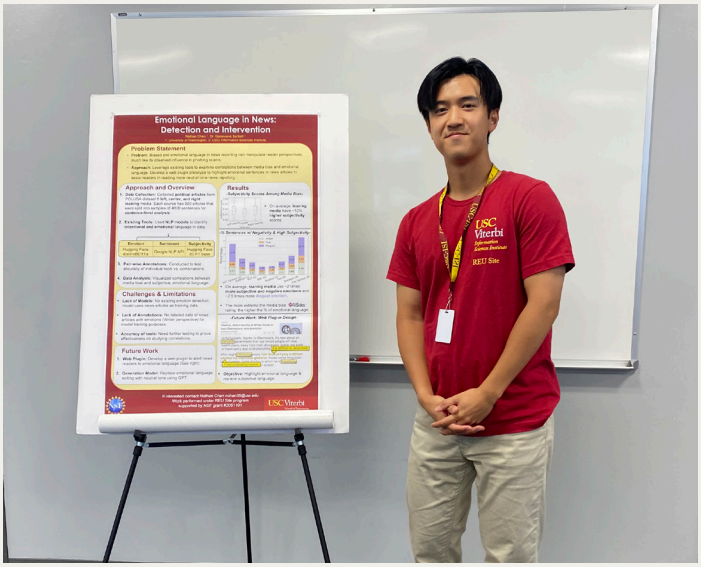
The Secure and Robust Electronics Center (SURE) focuses on secure, robust hardware R&D to help protect national security, advance industry capabilities and competitiveness, and ensure that citizens can rely on the integrity of their devices. SURE researchers perform applied research to make chips trustworthy, secure, resilient, and reliable.

The center investigates state-of-the-art manufacturing complexities that have compromised critical aspects of chip production. The more powerful integrated circuits become, the more opportunities arise for their integrity to be compromised. SURE researchers also aim to accelerate the scale, pace, and impact of hardware robustness and technology development.

The center's work has been supported by government agencies and by industry partners, including Xilinx Inc, Altera Corporation, Synopsys, and Cadence. Academic collaborators include Stanford University, Virginia Tech, Brigham Young University, Arizona State University, University of North Carolina, and Georgia Tech Research Institute.

Student research *programs*





Rising Star MS Internship Program

ISI offers Rising Star Internships to students applying to the Viterbi School of Engineering Master of Science program in computer science, data science, electrical and computer engineering, and related disciplines. The interns collaborate on an ongoing project with a research team — and work directly with an individual mentor throughout the course of the master's degree. Currently, one intern is working with researchers in the Informatics Systems Research Division on data management for the World in a Cell transmedia project, with computer scientists, biologists, and film school researchers; another intern is developing an automated shell script parser to perform safe de-obfuscation of malicious shell scripts. Past interns worked in analyzing malware samples and knowledge graph profiles.

Summer Internship Program

ISI welcomes Ph.D. students, master's degree students, and undergraduates every summer as paid interns to work with senior research leaders and their teams. The internships are available at all three ISI locations, and interns may work on-site or remotely with their ISI mentors and research teams.

Interns work in all ISI research divisions in data science, hardware security, machine learning, natural language processing, quantum information science, and other areas. In addition to research, interns participate in seminars, reading groups, and social activities.

SPHERE Internship

The SPHERE project, funded by the National Science Foundation, builds a common research infrastructure for cybersecurity and privacy research and education. In 2024, the SPHERE project hosted eight interns. These eight interns joined the SPHERE team at ISI for eight weeks over summer, and were engaged in infrastructure design, construction, and setup. They worked on a range of tasks, including: installing hardware, automating network configuration, scripting software installation, building testing frameworks for SPHERE front-end and backend, and building new user interfaces to support use of SPHERE in education. At the end of their internship the interns presented their work via posters and demos. The work has since been integrated with SPHERE's production hardware and software, greatly enhancing infrastructure stability and user experience. In year two, the SPHERE team plans to recruit 20 interns and involve them in a wider array of tasks, including installation of novel hardware, new user interface development, and improving accessibility of SPHERE.

CI Compass

The U.S. National Science Foundation (NSF) funds some of the most advanced scientific infrastructure in the United States, spanning domains from astrology and oceanography to physics and climate science. For young professionals, a job at one of these sites, known as NSF Major Facilities, offers the opportunity to contribute to groundbreaking research with real-world impact. However, many students are unaware of this exciting career path. This lack of awareness often leaves NSF Major Facilities struggling to find qualified technical specialists.

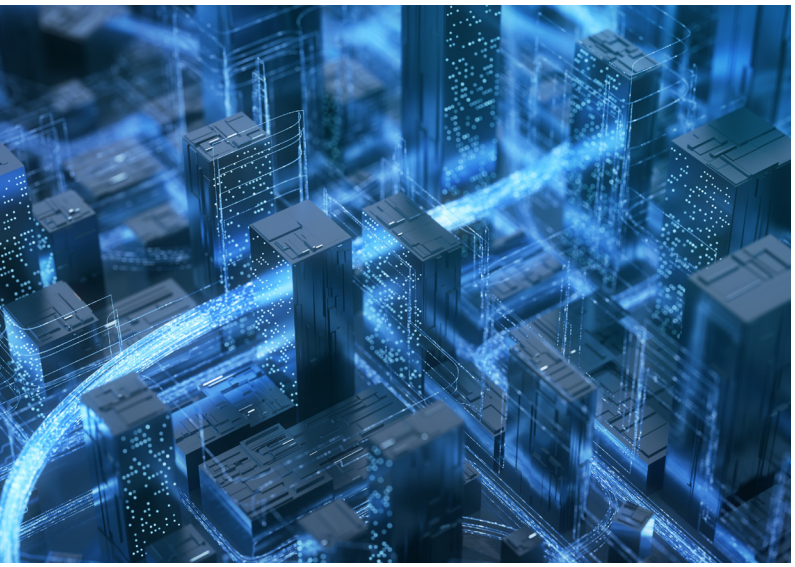
Recognizing this gap, Ewa Deelman, a research director at ISI, spearheaded the creation of the CI Compass Fellowship (CICF) Program in 2022. The initiative, part of CI Compass, an NSF Center of Excellence to strengthen the national cyberinfrastructure ecosystem, introduces undergraduates to the critical role of data and computing systems in advancing scientific discovery.

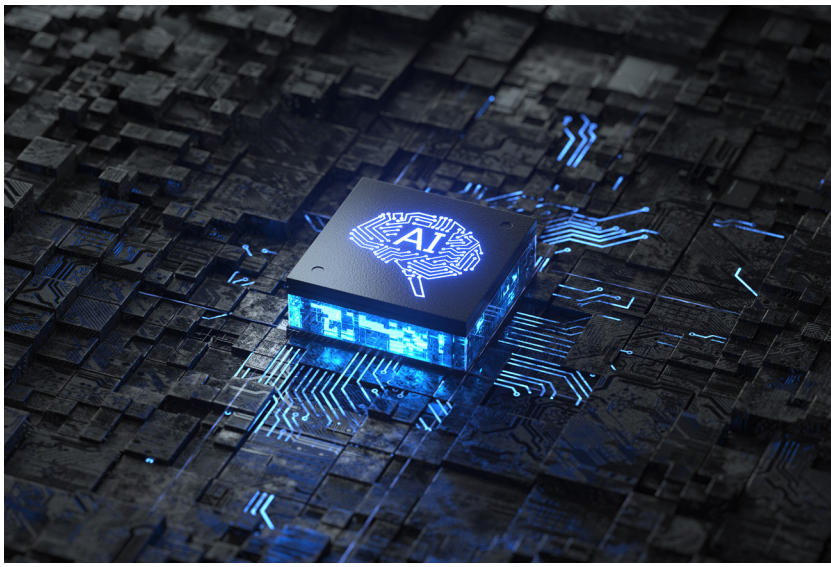
Now in its fourth year, CICF consists of two key components designed with undergraduate students in mind: a 12-week virtual spring training and a competitive 10-week summer internship. The spring program, free for undergraduate students from any U.S. college or university, covers both technical skills and an introduction to the data lifecycle at major facilities. Curriculum topics, many of which draw directly from ISI's expertise, range from Python programming and cloud computing to professional communications and networking skills. Today, select fellowship students progress to the summer program, where they're placed at NSF major facilities or cyberinfrastructure-related institutions. This experience has been the highlight for many students. Looking ahead, the CI Compass team aims to secure more summer internship spots.

Natural Language Internship

We recruit qualified students (graduate and undergraduate) to spend the summer working with ongoing research projects at ISI on natural language processing, machine learning, statistical modeling, machine translation, creative language generation, and other areas. These are paid internships. They are available for a three-month (12-week) period during the summer. Jonathan May, research associate professor, supervises those internships. Good programming skills are required, but prior experience in natural language processing is not necessarily required. We provide tutorials on relevant topics at the beginning of the summer.

Funding *highlights*





ALICE - ASSESSING LLM INTEGRITY FOR CLINICAL ENGAGEMENT
PI: MARJORIE FREEDMAN; CO-PIS: ELIZABETH BOSCHEE, JONATHAN MAY
Advanced Research Projects Agency for Health (ARPA-H). The ALICE project develops automated methods to evaluate medical chatbots based on stakeholder needs like interpretability and urgency. By generating test questions and assessing issues like hallucinations, it integrates insights from surveys and focus groups to align with patient, parent, and medical professional priorities.

AQUARIUS - ACCELERATED QUANTUM RESEARCH INTEGRATION FOR USABLE SECURE NETWORKS
PI: STEPHEN SCHWAB
CO-PIS: JONATHAN HABIF, JOHN WROCLAWSKI
DARPA I2O. The AQUARIUS project aims to develop quantum-augmented networking technologies, including a quantum-augmented network interface card and a software framework for integrating this hardware into existing systems. These innovations are designed to enhance classical networks with new security and trustworthiness properties.

FACEBASE IV - USC FACEBASE IV CRANIOFACIAL DEVELOPMENT AND DYSMORPHIA DATA MANAGEMENT AND INTEGRATION HUB
PI: CARL KESSELMAN
National Institutes of Health (NIH), National Institute for Dental and Craniofacial Research (NIDCR). The FaceBase Consortium, launched by the NIDCR in 2009, advances dental, oral, and craniofacial (DOC) research by providing comprehensive datasets on craniofacial development and disorders. As a central resource for the research community, FaceBase supports data sharing and collaboration. We aim to expand outreach, enhance services for a growing user base, and strengthen project management to meet evolving research needs.

CALIFORNIA DREAMS - CALIFORNIA DEFENSE READY ELECTRONICS AND MICRODEVICES HUB
PI: STEPHEN CRAGO
DoD Microelectronics Program, OUSD (R&E). In its second year, CA DREAMS/MOSIS 2.0 expanded through collaborations with two microelectronics hubs, enhancing support for rapid prototyping. The effort also grew with two major projects in 5G/6G and EW, demonstrating accelerated prototypes for phased arrays and GaN RF amplifiers while advancing MOSIS 2.0 capabilities.

SSTI-ISO - SPACE STRATEGIC TECHNICAL INSTITUTE FOR IN SPACE OPERATIONS
PI: DAVID BARNHART
Air Force Research Laboratory (AFRL) through Texas A&M University. The USSF Strategic Technical Institute for In-Space Operations (SSTI-ISO) is a five-year, multi-university consortium advancing space access, mobility, and logistics for AFRL and the US Space Force. As the largest SSTI for in-space operations, it funds up to three projects per university annually, covering fundamental research, applied extensions, and cross-university collaboration. USC SERC/ISI, selected for its successful technology transitions, will work with partner institutions to drive innovation and support both blue and red team applications.

CIFT - COMPREHENSIVE INDEPENDENT FUNCTIONAL TESTING OF FPGAS
PI: TRAVIS HAROLDSEN
Naval Surface Warfare Center. The CIFT project develops tools for Independent Functional Testing of FPGAs (Field Programmable

In 2024, ISI received 45 new funded research awards, some of which are listed below. Sponsored by the federal government, industry, and philanthropy, the awards range from tens of thousands of dollars to millions. The basic and applied research supported by these awards spans many areas: quantum information science, machine learning, microelectronics, cybersecurity, and more.

PHOTOGRAPHS BY **ISTOCK**

Gate Arrays) in critical infrastructure and weapons systems, supporting high-assurance requirements like supply chain validation and counterfeit detection. Using unconventional design techniques, CIFT generates test circuits to identify faults across millions of FPGA components. Phase 5 expands testing to next-gen Altera and MicroChip FPGAs, new hard IP blocks, and parametric delay testing for device health assessment.

TREBUCHET - FULLY HOMOMORPHIC ENCRYPTION ACCELERATOR
PI: MATTHEW FRENCH
DARPA MTO (through Duality Technologies). The Trebuchet project is developing a hardware accelerator for Fully Homomorphic Encryption (FHE), addressing its extreme computational cost. By adapting the architecture for 64-bit data and enhancing scalability, the project aims for a tape-out in November 2025.

CHIRON - Complementing Human Intelligence to Recognize Opponent Narratives
PI: Jonathan May
DARPA. The goal of CHIRON is to provide a dialogue model advisor to a human user, forming a human-machine hybrid, or centaur. When this centaur is involved in discussion with some counterpart, the advisor receives inbound communication attempts. CHIRON will help players in the closed-world game of Diplomacy.

SMART AND CONNECTED COMMUNITIES FOOD ENVIRONMENT DYNAMICS (SCCFED): LEVERAGING AI AND HUMAN MOBILITY DATA TO ADDRESS DISPARITIES IN FOOD ACCESS AND IMPROVE AMERICANS' DIETS
PI: ABIGAIL HORN
CO-PIS: KAYLA DE LA HAYE (USC DORNSIFE), ESTEBAN MORO (NORTHEASTERN UNIVERSITY)
NSF Smart & Connected Communities (S&CC). The SCCFED project leverages a large body of anonymized human mobility data collected from smartphones of approximately 15 million U.S. adult residents and develops novel methods in AI to extract insights on how the places people spend time in throughout their daily routines causally influence their dietary choices. The research team works with partners in policy at the Los Angeles County (LAC) Department of Public Health and the Department of Regional Planning to co-design, estimate potential impacts of, and pilot test interventions to food environments to optimally increase equitable access to healthy foods.

GREEK ROOM PHASE 3 - GRANULAR CHECKING FRAMEWORK FOR IMPROVING QUALITY AND SPEED OF BIBLE TRANSLATION
PI: ULF HERMJAKOB
Wycliffe Bible Translators. The Greek Room supports Bible translators and quality assurance teams with new AI tools to help them translate the Bible to new languages better and faster. Phase 3 of the project provides additional and improved checks, including spell checking, more languages, and integration with other Bible translation tools.

SHIELD - STRATEGIC HERPESVIRUS IMMUNE EVASION AND LATENCY DEFENSE
PI: FRED MORSTATTER
ARPA-H Health Science Futures. The SHIELD project aims to develop life-saving vaccines against a broad array of herpesviruses that infect the majority of Americans and can cause cancer, autoimmune disease, and birth defects.

Keston *Exploratory* Research Awards

ISI received a generous endowment gift in November 2015 from Los Angeles entrepreneur, philanthropist, and engineer-at-heart Michael Keston and his wife and philanthropic partner, Linda Keston. The Kestons endowed ISI's Keston Executive Director chair. In addition to endowing the director's chair, a portion of the income from the Keston endowment is dedicated each year to sponsoring the Keston Exploratory Research Awards, intended to foster and support exploratory early-stage research not yet funded by outside sponsors. ISI has contributed additional funds to expand the program, creating the ISI Exploratory Research Awards. The Keston and ISI Exploratory Research Awards support research projects that are intellectually intriguing, significant to society, and have the potential to produce results within a year or so. The following describes the work carried out in 2024 under the aegis of the Keston and ISI Exploratory Research Awards program.

MICHAEL KESTON AND HIS WIFE AND PHILANTHROPIC PARTNER, LINDA KESTON

2024 KESTON AWARDS

ACCELERATING FUNGAL GENOMIC INSIGHTS THROUGH INTEGRATION OF LLMS WITH ADVANCED SEQUENCING TECHNOLOGY

Alexander Titus

The project focuses on enhancing biosecurity by quickly characterizing fungal species using state-of-the-art sequencing technology alongside Large Language Models like ChatGPT. This combination enables on-site, real-time genomic analysis, increasing the speed and accuracy of identification. The project involves integrating systems and developing APIs, training and testing AI with an extensive fungal genome database, and implementing and validating with diverse samples. Outcomes include a prototype system, novel genomic insights, and open-source tools, contributing significantly to mycological research and biosecurity.

ADMIN: AI-GENERATED IMAGE DETECTION VIA MODEL INVERSION

Mohamed Hussein, Amir Kalev

Generative models have revolutionized the field of text-to-image synthesis with state-of-the-art technologies, such as DALL-E and Midjourney. These innovative models excel at blending learned concepts to produce novel, realistic images at an unprecedented pace and ease, opening doors to myriad applications. However, this capability is a double-edged sword, as it also empowers malicious actors to create damaging content, spread misinformation, amplify societal biases, or violate copyrights. This project introduces a novel approach through model inversion. The proposed paradigm offers a robust solution without altering the image generation process. Our project provides a much-needed forensic tool in the era of generative AI, enhancing digital content's safety and integrity.

2024 ISI EXPLORATORY RESEARCH AWARDS

DETECTING BIAS IN THE LAW - Jonathan May, Jonathan Choi (USC Gould school of Law)

We anticipate the use of LMs in the acceleration of legal decision-making, an especially important and high-risk domain. We believe the first step to combating bias is to identify it, ideally before actual harm is done. In this work we will develop techniques for systematically detecting bias in text, specifically in the legal subdomain.

EFFICIENT AND TRUSTWORTHY DISTRIBUTED LLM INFERENCE SYSTEM FOR PERSONALIZED SMART HOME ASSISTANTS - John Paul Walters, Stephen Crago, Peter Beerel

This project will develop a secure distributed LLM inference system composed of local edge devices. We will address security through targeted redundancy and cryptographic processing across a subset of the most sensitive weights. Efficiency will be addressed through model compression within a pipeline-parallel distributed environment.

We would like to highlight the exceptional achievements of our researchers, who have been recognized for their outstanding contributions to the field of computing. These honors also underscore the wide-ranging impact and recognition of their work on a global scale.

YOLANDA GIL

2024 PRESIDENTIAL APPOINTMENT TO THE NATIONAL SCIENCE BOARD

Yolanda Gil, principal scientist, ISI fellow and senior director for Strategic Initiatives in AI and Data Science at ISI, was appointed in October 2024 by United States President Biden to the National Science Board (NSB), a prestigious group of just 25 members who govern the National Science Foundation (NSF) and advise the President and Congress on science and technology policy. The NSB sets NSF's strategic direction, oversees its budget, and addresses critical national issues in research and education.

Gil has made significant contributions to AI-driven scientific discovery, semantic workflows, knowledge capture, and data provenance. She has led multiple national and international initiatives, including co-chairing the 20-Year AI Research Roadmap for the U.S., and has played a key role in establishing web standards for trust and transparency. Her appointment to the NSB is a testament to her impact on AI and her leadership in shaping science policy at the highest levels.

EWA DEELMAN

2024 APPOINTMENT TO THE INTERNET2 BOARD OF TRUSTEES

Ewa Deelman, principal scientist and ISI Fellow, has been appointed to the Internet2 Board of Trustees, which provides strategic direction and oversight for the nonprofit technology community supporting research and education institutions. She is serving a term from July 30, 2024, to October 31, 2026.

A leading researcher in distributed computing, Deelman develops workflow automation tools that power data-intensive scientific discoveries in fields such as astronomy, bioinformatics, and earthquake science. Her expertise in high-performance computing and cyberinfrastructure has shaped national strategies for scientific computing.

Internet2 serves hundreds of universities, government agencies, and research networks worldwide. Deelman's appointment reflects her leadership in advancing technology for scientific discovery and her role in shaping the future of research infrastructure.

LUCA LUCERI

2024 ISSNAF EMBASSY OF ITALY AWARD FOR RESEARCH IN ARTIFICIAL INTELLIGENCE

The ISSNAF (Italian Scientists & Scholars in North America Foundation) honored research associate professor Luca Luceri with this award, which recognizes Italian researchers in the U.S. providing fundamental contributions to all aspects of artificial intelligence, including technological and engineering advancements, transformative applications across disciplines, education, economic impact, ethical development to support societal needs, and solutions to mitigate harmful use of AI.

Luceri was awarded the Embassy of Italy Award for his work on AI-driven approaches for countering online harms on social media. His research tackles issues like online manipulation, and supporting vulnerable users. He develops computational tools to detect malicious activities and to enhance the resilience of information ecosystems, contributing to AI for social good.

Publications *highlights*

ISI takes immense pride in its extensive portfolio of research publications, a testament to our commitment to advancing the field of computer science. Our researchers have not only made significant contributions to top-tier conferences worldwide but have also authored influential books that further the breadth of knowledge in their respective domains. This curated list showcases the innovative work and thought leadership that define our institute's contribution to the global scientific community.

BINHUNTER: A FINE-GRAINED GRAPH REPRESENTATION FOR LOCALIZING VULNERABILITIES IN BINARY EXECUTABLES
2024 Annual Computer Security Applications Conference (ACSAC)
S. Arasteh, J. Mirkovic, M. Raghothaman, C. Hauser
BinHunter introduces a novel graph-based tool that combines control and data dependency graphs to detect software vulnerabilities in binary programs, achieving higher true positive rates and lower false positive rates than existing methods across multiple datasets.

MERGE/SPACE: A SECURITY TESTBED FOR SATELLITE SYSTEMS
2024 Workshop on the Security of Space and Satellite Systems (SpaceSec)
M.P. Collins, A. Hussain, J.P. Walters, C. Ardi, C. Tran, S. Schwab
Merge/Space (M/S) is a testbed for simulating multiple-agent security scenarios in satellite networks, combining orbital data with synchronized images to model bandwidth and connectivity constraints. The testbed enables analysis of various security threats, such as DoS attacks and malware infiltration, and includes sample datasets for release.

EBB AND FLOW: IMPLICATIONS OF ISP ADDRESS DYNAMICS
2024 Proceedings of the Passive and Active Measurement Workshop
G. Baltra, X. Song, J. Heidemann
This paper presented the first evaluation of ISP-wide use of Internet Protocol (IPv4) addresses. He shows that some ISPs are durnal, using many more addresses during the day than they do at night. His work helps us improve detection systems for Internet outages, by avoiding false detections, and it helps evaluate how many IP addresses are actually used in each ISP, an important factor now that all IPv4 addresses have been allocated.

SYNTHETIC DATA GENERATION FOR MACHINE LEARNING MODELS WITH COGNITIVE AGENT SIMULATIONS
2024 Practical Applications of Agents, Multi-Agent Systems, and Digital Twins (PAAMS)
J. Blythe, A. Tregubov
This paper examines how synthetic data from cognitive agent simulations can enhance ML performance on social media tasks, showing improved prediction accuracy for code quality and bot detection through combined real and synthetic training data.

PREDICTIVE PERFORMANCE OF PHOTONIC SRAM-BASED IN-MEMORY COMPUTING FOR TENSOR
2024 IEEE High Performance Extreme Computing Conference, best paper award
S. Wijeratne, S. Sunder, M. A.-A. Kaiser, A. Jaiswal, C. Mathew, A. P. Jacob, V. Prasanna
This paper presents a novel Photonic SRAM architecture that replaces conventional memory with ultra-fast, light-based storage. The system accelerates tensor decomposition operations, achieving 17 PetaOps performance—a massive leap over existing technologies.

OPTICALLY BIASED AND CONTROLLED SIGNAL PROCESSING IN SILICON PHOTONICS OPTICS EXPRESS
S. Idres, J. Habif, H. Hashemi
This paper demonstrates a revolutionary data-processing function that performs operations directly on data flowing through optical fiber, reducing the latency of optical-to-electrical conversion. The demonstration was implemented on silicon photonic integrated circuits fabricated in an industrial foundry.

USING OPEN-SCIENCE WORKFLOW TOOLS TO PRODUCE SCEC CYBERSHAKE PHYSICS BASED PROBABILISTIC SEISMIC HAZARD MODELS
Frontiers in High Performance Computing
S. Callaghan, P. J. Maechling, F. Silva, M.-H. Su, K. R. Milner, R. W. Graves, K. B. Olsen, Y. Cui, K. Vahi, A. Kottke, C. A. Goulet, E. Deelman, T. H. Jordan, Y. Ben-Zion
This paper describes how the Statewide California Earthquake Center leverages Pegasus WMS for their Cybershake Platform for calculating physics-based probabilistic seismic hazard analysis models. Using this platform, SCEC completed CyberShake Study 22.12 during which Pegasus managed approximately 32,000 jobs, and used up to 73% of the Summit system at Oak Ridge Leadership Computing Facility.

A QUANTUM MONTE CARLO ALGORITHM FOR ARBITRARY SPIN-1/2 HAMILTONIANS
Physical Review Research
L. Barash, A. Babakhani, I. Hen
This paper presents a general approach for

PHOTOGRAPH BY **JARUEK CHAIRAK/ISTOCK**

learning the equilibrium properties of a broad class of physical models using quantum Monte Carlo simulations. Their methodology introduces the first algorithm capable of accurately simulating a wide range of models across diverse settings under a single simple framework.

LEVERAGING LARGE LANGUAGE MODELS TO DETECT INFLUENCE CAMPAIGNS IN SOCIAL MEDIA
The Web Conference 2024
L. Luceri, E. Boniardi, E. Ferrara
This paper introduces a methodology designed to identify users orchestrating information operations across various influence campaigns. The research marks a step toward developing Graph Foundation Models specifically tailored for the task of IO detection on social media platforms.

***GET THE** LIST*

AFFECTIVE POLARIZATION AND DYNAMICS OF INFORMATION SPREAD IN ONLINE NETWORKS - *NPJ Complexity*
K. Lerman, D. Feldman, Z. He, A. Rao
This paper reveals how emotional polarization manifests in online social networks. The study shows how emotional patterns scale with network distance, with closer connections fostering positive emotions and distant ones generating more negative responses.

THE DIFFUSION OF CAUSAL LANGUAGE IN SOCIAL NETWORKS
2024 International AAAI Conference on Web and Social Media
S. Zhuoyu, F. Morstatter
This research demonstrates that messages containing causal language spread more effectively through social networks than those without. The study of Twitter communications reveals that causal language helps messages reach broader audiences and cross ideological boundaries, potentially offering a way to bridge echo chambers.

A FEDERATED LEARNING ARCHITECTURE FOR SECURE AND PRIVATE NEUROIMAGING ANALYSIS *PATTERNS*
D. Stripelis, U. Gupta, H. Saleem, N. Dhinagar, T. Ghai, C. Anastasiou, R. Snchez, G. Ver Steeg, S. Ravi, M. Naveed, P. Thompson, J.L. Ambite
This paper advances privacy-preserving AI for Alzheimer's research through federated learning, enabling neural networks to train across multiple hospitals without sharing sensitive data. This work enables secure collaboration across 12 research sites while maintaining patient privacy, achieving over 90% accuracy in detecting Alzheimer's from brain scans.

SELF-DISCOVER: LARGE LANGUAGE MODELS SELF-COMPOSE REASONING STRUCTURES - *Neural Information Processing Systems*
P. Zhou, J. Pujara, X. Ren, X. Chen, H.T. Cheng, Q. Le, E. Chi, D. Zhou, S. Mishra, H.S. Zheng
This research introduces SELF-DISCOVER, a framework that empowers large language models to identify and compose their own reasoning strategies. SELF-DISCOVER achieves up to 32% performance gains on complex reasoning tasks while using 10 to 40x less compute than current methods.

Their lives *after* ISI

Former ISIers recall how their time at ISI made them the researchers they are today, and how it accelerated their career.

POSTDOCTORAL RESEARCHER AT ISI FROM 2021 TO 2024

"ISI was instrumental in helping with my transition from a graduate student to a faculty member"

Emmanuel Dorley, now tenure-track Assistant Professor at the University of Florida

The people at ISI make it what it is. I was also able to meet other faculty members and an amazing postdoc mentor who helped me put together a strong application for a faculty position, as well as think through the next stages of my career. The interdisciplinary work happening at ISI has reaffirmed my view of the field of computing as very interdisciplinary, requiring you to consider both the technical and the social, human-centric nature of the technologies we build.

GRA AT ISI FROM 2016 TO 2017

"Fascinated by the research in the networks and security domains"

Ameya Hanamsagar, now Security Engineer at Meta

I worked at ISI while doing my M.S. in Computer Science at USC. Now I work as a Security Engineer at Meta on integrity problems related to social harms. I still remember an interview for the position where I was able to apply the techniques we had experimented with at ISI for a system design problem. ISI helped me build the muscle to scope complex problems in stages, which I continue to benefit from during prioritization roadmapping.

ELECTRICAL ENGINEER INTERN IN 2014/15

"ISI opened my eyes to the accessibility of being part of innovative projects"

Jade Macabulos, now Electrical Engineer at Northrop Grumman Corporation

I was an Electrical Engineering intern for ISI's Space Engineering Research Center (SERC) during my undergraduate years from 2014 through 2015. I am still amazed that my first career out of college was pretty much the same role I had at SERC – just on a bigger scale. ISI helped foster my interest in electrical system engineering for space products, and I was able to build confidence in the beginning of my career to find something I really wanted to do and to excel in. It felt like the stars aligned.

RESEARCH ASSISTANT PROFESSOR

"I had amazing growth during my time at ISI"

Filip Ilievski, now Senior Assistant Professor at Vrije Universiteit Amsterdam

I was at ISI from 2019 until 2023. I joined as a temporary-contract Computer Scientist, got promoted into a permanent position, and in 2022 became a Research Lead and Research Assistant Professor at USC. ISI is where I developed my research line on common sense AI, won my first proposal, and learned from excellent mentors and colleagues. At ISI, there is a large pool of people with wide and ever-growing interests that you can partner with. And finally, the offices have a great view, coffee is excellent, yoga is regular, and students are smart and dedicated.

GRA AT ISI FROM 2019 TO 2020

"Stay focused and curious, and build meaningful connections"

Rutuja Rane, now Staff Data Science Product Manager at Walmart

Working alongside seasoned researchers at ISI exposed me to diverse perspectives and best practices in the field. Their invaluable mentorship helped me refine my problem-solving abilities and analytical thinking skills. My new role marks a pivotal point in my professional journey, allowing me to leverage my expertise in data science and product management to drive innovation and efficiency within one of the world's largest retail organizations.

PH.D. STUDENT, POSTDOCTORAL RESEARCH ASSOCIATE FROM 2002 TO 2007

"My research area moves fast"

Liang Zhou, now Managing Director, Head of Applied AI/ML at JP Morgan Chase & Co. Consumer Bank

I joined ISI in January 2002 as a first-year Ph.D. student and continued on as a postdoctoral researcher from 2006 to 2007 in the AI Division with the Natural Language Processing group. ISI, along with its professors, scientists, and students, helped to build the foundations of my understanding of AI and NLP. Through rigorous research and collegial discussions and debates, I learned how to conduct research, think deeply and critically about problems, create and experiment with different solutions and finally, perform error analyses to understand the core goals.

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REMOTE RESEARCHERS

2024 YEAR *in* REVIEW

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