Coordinated Science Lab Newsletter
GRAINGER COLLEGE OF ENGINEERING

FALL 2020

CONNECT

CSL Rises to the Challenge of COVID-19

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Grainger College of Engineering
Coordinated Science Lab

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CONNECT

Director's Message | Klara Nahrstedt

Without a doubt, 2020 has presented unparalleled physical and emotional challenges, altering the way we live, work, and play. CSL, along with the rest of the University, has worked very hard to adjust to the new reality; now, well into the Fall 2020 semester, many CSL members are still working offsite as much as possible in order to help keep vulnerable faculty, students, and staff healthy.

Even so, COVID-19 also has presented unique opportunities for CSL researchers, who have jumped to contribute to the scientific knowledge that will be needed to defeat the virus. I have been so pleased to see how CSL researchers have responded and are continuing to respond to the call for highly efficient and effective data analytics tools, machine learning systems, techniques for virus spread and virus mitigation modeling, applications, and other innovations needed to limit COVID-19's impact.

Some researchers are pursuing entirely new projects and initiatives for COVID-19. For example, CSL's R. Srikant and Tandy Warnow are helping to lead the C3.ai Digital Transformation Institute (DTI), which brings top scientists together to solve global problems, such as the current pandemic. CSL researchers are involved with five of the 26 C3.ai DTI projects that aim to help mitigate SARS-CoV-2 and future pandemics.

In response to the urgent needs brought on by the pandemic, the Health Care Engineering Systems Center, through the Jump ARCHES collaboration, also funded 16 COVID-related projects that aimed to produce solutions that could be deployed quickly, within four to six weeks. CSL researchers were involved with five of these projects.

In other cases, CSL researchers are applying previous research to SARS-CoV-2. In 2013, for example, Carolyn Beck began studying how epidemic models work based on network structures, taking into consideration the infection rate, healing rate, and recovery rate. When COVID-19 struck, her work immediately became relevant to the current pandemic. For another example, Ravi Iyer, who has been working with Mayo Clinic on modeling of genomic data for years, is now seeing his research applied to COVID-19 data.

And those are just a few of the CSL faculty members and students who are contributing to the fight.

While the past months have not always been easy, I have been so impressed with how everyone has adapted to the new mode of work. The pandemic has demonstrated that CSL is an organization whose mission and vision remain strong, wherever we may be physically.

GRADUATE HIGHLIGHTS

As final semesters go, Spring 2020 was unprecedented. While the traditional graduation ceremony and many of the celebrations that go along with it were canceled, we wanted to recognize what some of our graduating students have contributed to research during their time at CSL and celebrate their future plans.

Girish Joshi graduated with his Ph.D. in aerospace engineering after studying under CSL faculty member Girish Chowdhary. The focus of Joshi's research was on improving the stability of autonomous aircraft. After graduation he took a job developing reinforcement learning algorithms at MathWorks in Boston, MA.

Sujan Gonugondla graduated with a Ph.D. in electrical and computer engineering after studying under CSL faculty member Naresh Shanbhag. He recently joined Amazon as a research scientist and will be working on new artificial intelligence and machine learning devices to make day-to-day tasks more efficient.

Wyatt McAllister defended his dissertation in the spring as a member of Chowdhary's lab. He received his Ph.D. in electrical and computer engineering and spent the summer working on TerraSentia robots to develop an extraction technique for weed density estimates. He recently entered the job market.

Haoyan "Carl" Zhang completed his B.S. in computer engineering last spring and started graduate school at Stanford this fall. As part of his undergraduate work with CSL professor Steve Lumetta, Zhang wrote a program that translates code written in the IA-32 assembly language into the LLVM compiler infrastructure language.

FACULTY HIGHLIGHTS

Illinois named Xilinx Center of Excellence

The University of Illinois at Urbana-Champaign has been named a Xilinx Center of Excellence for Adaptive Computing. The designation comes with a significant donation from Xilinx, a California-based supplier of adaptive and intelligent computing devices. It includes a large number of high-end adaptive compute acceleration platforms that will be used to build a heterogenous computing cluster called the Xilinx Adaptive Compute Cluster (XACC) in Illinois' Coordinated Science Lab. XACC will be part of a university research program recently announced by Xilinx.

Xilinx has also donated and committed gift grants to support several multi-year research projects in the center. The center will be directed by CSL Professor Deming Chen.

Kumar honored with two test-of-time awards

Twice this year, CSL's Rakesh Kumar received awards for most influential papers.

At the Asia and South Pacific Design Automation Conference, he received the Ten-Year Retrospective Most Influential Paper Award for his paper "Slack redistribution for graceful degradation under voltage overscaling." Later in the spring, his paper "Interconnections in multi-core architectures: Understanding mechanisms, overheads and scaling" was named the winner of the 2020 ACM SIGARCH and IEEE-CS TCCA ISCA Influential Paper Award.

The point of such "test-of-time" accolades is to honor work that doesn't just dazzle its initial readers, but proves over time that it has significant and lasting value.

Sarita Adve elected to American Academy of Arts and Sciences

CSL faculty member Sarita V. Adve is one of two University of Illinois at Urbana-Champaign faculty members elected in 2020 to the American Academy of Arts and Sciences, one of the oldest honor societies in the nation. She is among 276 new members elected to the Academy this year.

Adve is the Richard T. Cheng Professor of Computer Science and an Information Trust Institute researcher. Her primary research interests are at the computer hardware-software interface and include computer architecture, programming languages, operating systems, and applications.

Remembering Thomas Huang, Maybelle Leland Swanlund Endowed Chair Emeritus in Electrical and Computer Engineering

Thomas S. Huang, a pioneering researcher and influential teacher, died on April 25, 2020, at the age of 83. In his long career, Huang was ranked among the world's most influential researchers and mentored more than 100 students.

In honor of Huang and his late wife, two alumni, James J. Kuch (MS '94) and Chang Wen Chen (PhD '92), joined forces to create the Thomas and Margaret Huang Fund for Graduate Research. Huang's legacy will also live on through a new Thomas and Margaret Huang Endowed Professorship in Signal Processing and Data Science in ECE, set up by his family.

CSL Rises to the Challenge of COVID-19

2020 has brought a global pandemic that has completely transformed our lives. But when times got tough, CSL researchers got to work. Here is a look at how CSL faculty and students have contributed to fighting COVID-19.

CSL professor researches video monitoring of patients

During the ongoing COVID-19 pandemic, a major concern for healthcare professionals has been a shortage of space to treat patients. CSL research professor Narendra Ahuja and his team are working to develop a way to monitor a patient's condition through video without using special instruments, making it possible to treat patients who are located at home or in other locations outside a healthcare facility. Ahuja's group has developed algorithms that use computer vision, audio analysis, and machine learning in order to use cameras and audio capture devices in much the same way that humans use their eyes and ears to understand their surroundings.

Use of a camera to video-monitor patients allows physicians to measure physiological parameters such as blood pressure, heart rate, respiratory rate, and other aspects of pulmonary health through the movement patterns of the chest, nostrils, and ribs. The captured audio provides various sounds from the human body that can be used to assess aspects of health, such as cough length, intensity, and frequency. In addition, sounds that reveal the articulation rate, effort, and auditory roughness, along with speech patterns, can also give clues about patient health.
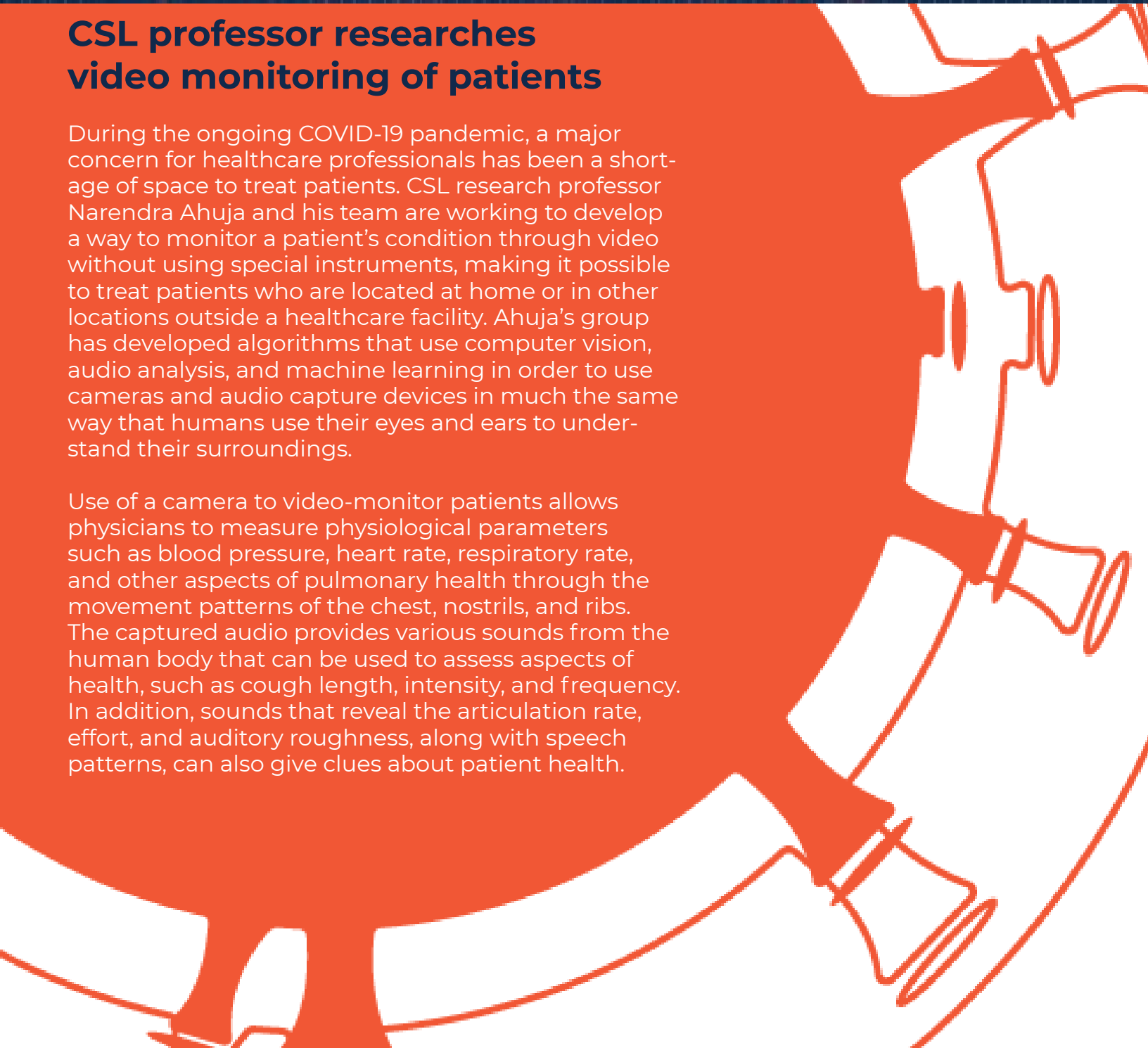
Illinois, Northwestern team up to track COVID-19 symptoms, disease progression

One of the greatest challenges in treating patients with coronavirus is an overall lack of information about how the disease progresses. In order for doctors and epidemiologists to gather enough such information accurately, many patients would have to be monitored 24/7 through the entire infection cycle. Researchers at Northwestern University and the University of Illinois at Urbana-Champaign have developed a way not only to collect the data through novel wearable devices, but also to organize and analyze the massive data sets to provide health professionals with an accurate picture of disease progression.

The sheer amount of data generated by the devices can be overwhelming for physicians or caretakers who are monitoring dozens of patients. When field tests of the device first began, the original 25 patients generated more than a terabyte of data in the first week. That's where CSL Professor Naresh Shanbhag's team came in.

Extracting that much data out of a patch barely thicker than a band-aid is no easy task. Shanbhag's group has two main goals in processing the data: to analyze the ever-growing set of data in the cloud and to move some of the processing to the patch to make the entire process more energy-efficient.

Wearable data collection device.

As algorithms are developed by Shanbhag's group, they will be deployed on the devices by former Illinois faculty member and current Northwestern University Professor John Rogers and his team. The devices will then provide improved data to Shanbhag. That feedback loop will improve the accuracy of the algorithms and reduce the complexity to enhance the capabilities of the next generation of wearable devices.

CSL researchers adapt robots to fight against COVID-19

When the novel coronavirus puts human workers at risk, robots can sometimes step in to do the job. CSL faculty member Girish Chowdhary and his research team previously developed a suitable robot, and they are now adapting it to the current needs. Chowdhary's robot, TerraSentia, is a small, semiautonomous robot that moves nimbly on the ground and was originally intended for agricultural and horticultural use. A team of these robots can work together, combining the speed and power of technology with the attention to detail of human labor. Their abilities can make them very useful in the fight against the novel coronavirus.


Girish Chowdhary and his TerraSentia robot.

One way to limit exposure to the coronavirus is to disinfect rooms and surfaces. Robots already exist that can disinfect a room by filling it with UV light for 20 minutes. However, the light is harmful to human skin, so people have to leave while the robot works. Chowdhary teamed up with CSL associate professor Kris Hauser, a renowned expert in healthcare robotics, to develop technologies that use UV lights, wiping, or other mechanism for disinfection.

Chowdhary's group will work on localization and mapping technology to enable the robots to work near humans as they move around in a hospital environment. A cloud-based system will make the robots traceable, showing which areas have been disinfected.

RapidVent/RapidAlarm developed to improve COVID-19 treatment

Perhaps the biggest story to come out of the Grainger College of Engineering this spring, was the development of RapidVent. The prototype emergency ventilator was made to help address the expected surge in the need for respiratory care associated with the COVID-19 pandemic.

CSL researchers Michael Oelze, Andy Singer and Ryan Corey were part of the development, and built an alarm to help improve the functionality. RapidAlarm uses a hearing aid algorithm and measures the pressure in a patient's airway. If the pressure drops below a certain level, the alarm sounds to alert medical staff.
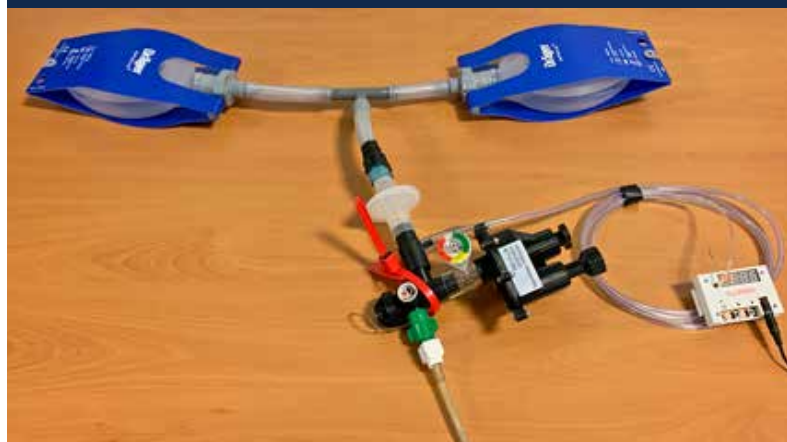

RapidVent/RapidAlarm prototype.

CSL alum explains the science behind the spread of COVID-19

It seems as though every hour there is a new update on where COVID-19 has spread and the new measures being taken to stop the spread. This coronavirus is able to spread quickly, even through people who are not showing symptoms. CSL alum and virus modeling expert Philip E. Paré has been studying why this illness is no ordinary flu.

Paré has been able to develop models that can predict the virus's spread and community impact. Paré, along with CSL's Carolyn Beck and Tamer Başar, have used dynamic models that capture a patient's movements throughout a virus outbreak, unlike previous models that kept a person's position static.

This new method allows them to model the spread of a disease more accurately, and understand and quantify how different distancing methods could work to help prevent spread.
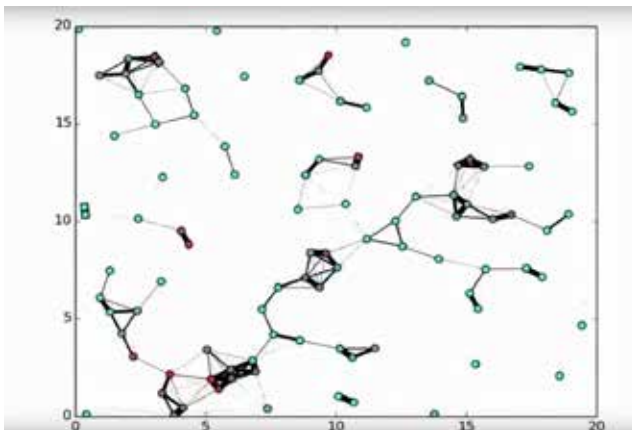
Abdelzaher repurposes social networking models to predict COVID spread

Since the COVID-19 pandemic began, there has been plenty of opportunity to observe how a vast array of truths, half-truths, and falsehoods can flare up and spread like wildfire across social media, swirl around, and just as quickly get buried and forgotten. It could have served as a fascinating case study for CSL and computer science professor Tarek Abdelzaher, who for years has studied how information propagates through social media.

However, he chose to do something very different. Abdelzaher and his team recognized that the dissemination of information through a population of online users is similar to the transmission of a virus through a population of flesh-and-blood human beings, and that realization inspired them to repurpose their information propagation models to predict COVID-19 spread. They have made the findings available to the public on an interactive website that offers predictive power not available elsewhere.

Disease spread model.
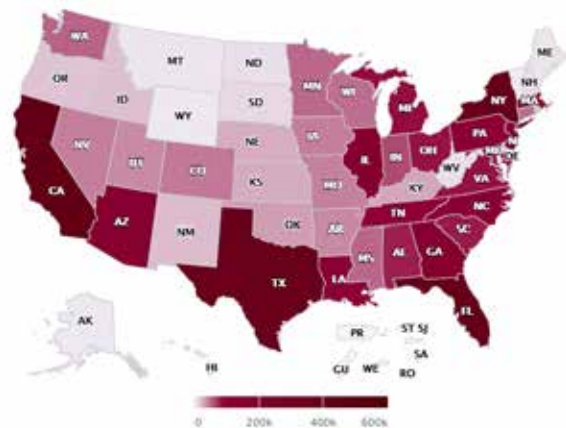
Map of pandemic transmission prediction.

Do COVID-19 apps protect your privacy?

Mobile apps are helping track the spread of COVID-19 to contain the outbreak, but the apps also raise concerns about personal privacy. CSL professor Masooda Bashir and her doctoral student Tanusree Sharma analyzed 50 COVID-19-related apps available in the Google Play Store to determine the extent of their access to users' personal data and what privacy protections they offer. Bashir and Sharma found that most of the apps required access to users' personal data, but only 16 indicated the data would be anonymous, encrypted, and secured.

Thirty of the apps require users to give them permission to access the mobile devices' data and/or features, such as contacts; photos, media, and other files; location data; the camera; the device's ID; call information; the Wi-Fi connection; the microphone; unique identifiers; the user's age and contact information; and network access, among others. The researchers acknowledge that mass surveillance measures may be necessary to contain the spread of the virus, but believe researchers in information privacy and security must ask the questions needed to determine whether privacy is being protected.

New C3.ai Digital Transformation Institute funds 5 CSL-led projects

CSL Professor R. Srikant is co-leading an institute whose goals include the use of artificial intelligence (AI) to defeat the novel coronavirus. The mission of the C3.ai Digital Transformation Institute (DTI), of which Srikant is co-director, is to bring together a group of the world's leading scientists in an innovative and coordinated effort to advance the digital transformation of society, business, and government. Because COVID-19 is such an urgent problem, the C3.ai DTI team, which includes CSL Professor Tandy Warnow as chief scientist, has set its sights on using the power of artificial intelligence to answer questions about what types of drugs patients are best responding to, what is the best approach to getting people back to work, and other important issues.

This summer, C3.ai DTI funded 26 research projects to help combat the COVID-19 pandemic. Researchers who received funding also gained access to the C3.ai computing Suite and Microsoft Azure computing and storage to help them complete their multidisciplinary projects. Five of the projects that received funding are being led by CSL researchers.

C3.ai Digital Transformation Institute

Fan wins 2020 CSL PhD Thesis Award

Chuchu Fan

For her exemplary work in addressing major societal problems related to autonomous verification, CSL alumna Chuchu Fan has been awarded the 2020 CSL PhD Thesis Award. This honor is bestowed annually on a researcher whose PhD thesis makes advances in a disciplinary area that has an interdisciplinary angle.

In 2013, Fan joined CSL Professor Sayan Mitra's research group. It was there that she spent 6 years working on developing formal verification and synthesis techniques to improve autonomous vehicle safety. During her time at CSL, she published five papers at the Computer Aided Verification (CAV) conference, a rare accomplishment, according to Mitra.

"Our innovation engine at CSL works because of the brilliant individuals like Chuchu that come to work with us from all over the world," said Mitra. "Chuchu stood out for her ability to be both deliberate and zealous. As Chuchu matured as a researcher and started to see her work get some visibility and success, she demonstrated discipline to continue to be uncompromising about the 'small' details."

Now starting a new role as a Wilson Assistant Professor of Aeronautics and Astronautics at MIT, Fan credits CSL with preparing her for such a position.

CSL professors lead effort to study the psychology of fake news

Tamer Basar

Michel Regenwetter

Cedric Langbort

Recently, there have been lots of stories about how everything from disease to fake news spreads. Many researchers have looked at how different kinds of spreading may be analogous and can be analyzed in similar ways. After all, whether a contagious agent or a bit of fake news is the thing being spread, it is passed via proximal contact throughout the population.

As part of a newly funded, $6.25 million Multidisciplinary University Research Initiative (MURI) project, CSL professors Cedric Langbort, Tamer Başar, and Michel Regenwetter are working with an interdisciplinary team to look at fake news from a dynamic and psychological standpoint, with the goal of more accurately understanding the spread.

"In the first wave of research on the spread of information over networks, researchers thought information was like a virus, in that what determined the spread is the structure of the network and its virus-like evolution," said Langbort. "More recent work is looking at the people element. If you have certain psychological traits, you may be more likely to retweet certain kinds of news."

A recent study from Sweden supports the hypothesis of the MURI project, which is titled "A multimodal approach to network information dynamics." The Swedish study found that if people care about what society or their online friends think of them, they may be more likely to share information those people would like and less likely to share a dissenting opinion. How much people value their societal identity and their social identification contributes to their behavior both online and offline. People's psychological and social traits can help predict whether they will interact with messaging and share it with others.

"We take into account the psycho-cognitive elements, but we don't treat them as immutable characteristics -- rather as dynamic messages themselves," said Langbort. "We're interested in isolating different modes of transmission. Are you trying to pass information to me because you're informing me, or are you crafting what you're sending me because you expect it to get me to do something?"

> **"...more than 50% of respondents think that by sharing either fake or real stories, they are going to influence others and make other people think the way they want them to think..."**

Persuasion, also known as influencing or manipulation, is sharing of information to change or shape the receiver's opinions so that they will be aligned with the sender's. It is one of the most studied reasons for sharing information. In a previous study conducted by The New York Times, it was found that more than half of people would share a story they thought would influence others, even if they knew it wasn't factual. That study influenced the MURI team's research plans.

"The really important conclusion of the Times study is that more than 50% of respondents think that by sharing either fake or real stories, they are going to influence others and make other people think the way they want them to think," said Başar, Swanlund Endowed Chair. "We are looking at what is the motivation of those who make up information and send it to others to shape their opinions, as well as on the receiving end, why people do not corroborate the validity of the information they have received and are willing to share with others."

For the last several years, Langbort and Başar have been developing a dynamic theory of persuasion built on game-theoretic approaches. They are working to build out this theory and understand how it is relevant to the persuasion mode. They hope eventually to build a more dynamic mathematical model to both explain and predict people's actions when it comes to sharing of misinformation.

Regenwetter will work to see if attempts to influence others by sharing information, whether true or false, are effective.

"One of the first questions we want to tackle is how participants in an experiment update beliefs based on exposure to true and false evidence," said Regenwetter. "A core question here is whether it is reasonable to model human decision-makers as people who intuitively follow the rules of probability theory (rational theory). There is lots of prior evidence that people don't follow probability calculus in their reasoning."

CSL students' paper selected for international reproducibility competition


Simon Garcia de Gonzalo

Mert Hidayetoğlu

Each year, computing teams from around the world gather to try to replicate the results of a carefully selected research paper as part of the Student Cluster Competition that happens at the annual Supercomputing Conference. This year, the selected paper was written by CSL students Mert Hidayetoğlu and Simon Garcia de Gonzalo.

Usually, when research is published, the paper includes the techniques and algorithms used so the research can be reproduced. However, in computing, simulations and algorithms often have "fragile" code that can't be replicated. Sometimes, when students graduate, the code infrastructure they've built leaves campus with them. If nobody can reproduce it, then other students can't build on that research. This is clearly an issue in the field, which means that writing a paper and code that can be reproduced is a big deal.

Participants in the Student Cluster Competition – which is scheduled to take place in November – will be judged on their ability to reproduce the results and conclusions in the CSL students' original paper, "MemXCT: Memory-Centric X-ray CT Reconstruction with Massive Parallelization." Each group will build its own system to replicate the results, with each one using different hardware and software.
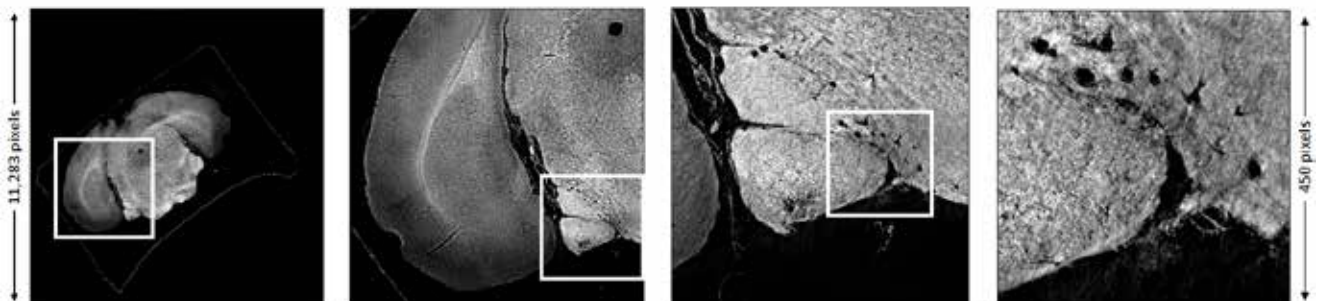
X-ray of mouse brain.

An Illinois-led study suggests opinion polarization is caused by data overload

It is commonly observed that the rise of social media seems to have been correlated with a rise in social and political polarization. Many theories have tried to explain the phenomenon, but a recent Illinois-led study concludes that the culprit might simply be information overload, and proposes new algorithms to help people navigate it better.


Humans are now inundated with real-time information, but their ability to absorb information has not increased. This means humans are chronically overloaded and see an ever-shrinking fraction of the ever-expanding amount of available information. As it becomes harder to navigate the growing menu of information sources and options, the natural instinct is to gravitate towards the familiar – the opinions and sources that support a person's already-held beliefs.

Information volume is a big culprit, the study confirms. When a search engine like Google returns 1,000,000 matches and a person reads the top three, chances are that he or she is not reading a representative sample, because search engines remember people's preferences and what sites they've visited before.

The solution, being developed by Abdelzaher and his collaborators, involves restructuring how search results are presented and sorting out results that include false information. Ideally, a web search will produce a vetted summary of all the results that presents multiple sides of an issue.

To achieve such a solution, Abdelzaher is relying on Illinois colleagues, including CSL's Alex Schwing. Schwing is a machine learning and vision expert who can extend the summarization to include visual information in addition to text.

With their combined expertise, the researchers are developing algorithms that can better organize search engine results, ensure their accuracy, and provide people with information that they might not otherwise have found, helping break them out of their thought bubbles.
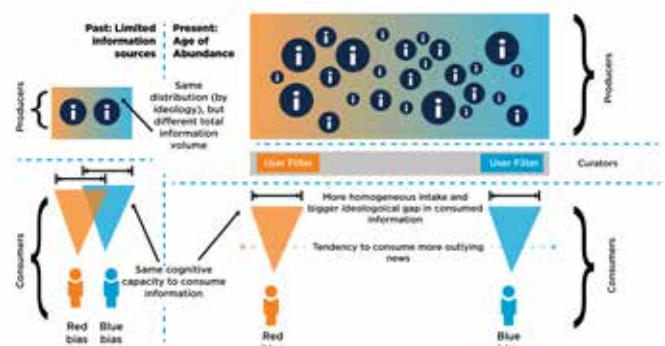
Data polarization diagram.

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