FALL 24

IMPACT

LYLES SCHOOL OF CIVIL AND CONSTRUCTION ENGINEERING

AI DRIVES INNOVATION

Faculty harness technology to pioneer new research methods

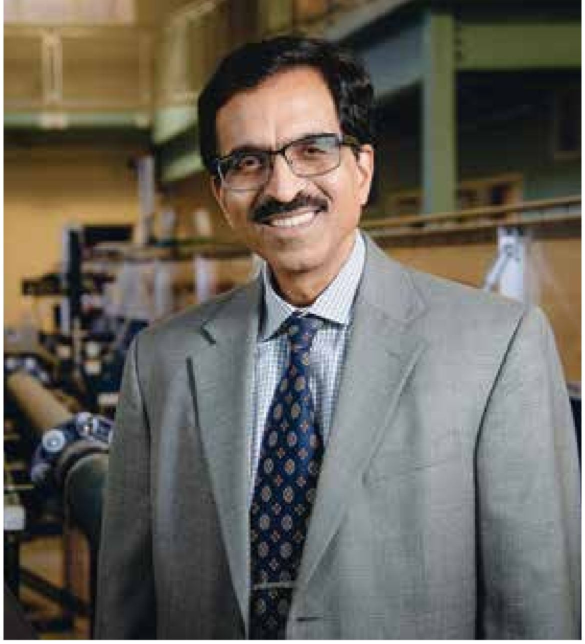
PAGE 6

PURDUE UNIVERSITY

Lyles School of Civil and Construction Engineering

MOSQUITO ANTENNAE MAY HOLD SECRETS TO DEVELOPING VIBRATION SENSORS | PAGE 12

MESSAGE FROM THE HEAD



The start of the fall semester has marked an exciting new era for our school.

On July 1, the school changed its name to the Lyles School of Civil and Construction Engineering. I am incredibly excited for this new phase as it will further strengthen our program and enhance educational experiences for our students. By merging with the Division of Construction Engineering and Management, we are now better able to meet industry demands — both nationally and internationally — that call for graduates who have a greater understanding of the civil and construction engineering fields.

Initial merger discussions began in 2023 when the College of Engineering, the School of Civil Engineering, and Division of Construction Engineering and Management agreed that there was an opportunity to better serve our students by offering new programs and opportunities at both the West Lafayette and Purdue University in Indianapolis campuses.

Another primary goal of this merger is to gain better alignment and timing of student offerings (such as internships, co-ops and study abroad opportunities) to minimize overlap of courses, while providing pathways to timely graduation. This move allows us to better deploy new options and opportunities, such as certificate programs and professional concentrations, at both the graduate and undergraduate levels — more effectively and efficiently.

More details on the merger can be found on page 2. This edition of *CCE Impact* also highlights how artificial intelligence is both enhancing and advancing our research in several areas. Other stories in this edition include our work on testing roads that can charge electric vehicles as they drive over it and taking inspiration from natural designs to innovate on materials and research into indoor air quality.

These research efforts are all assisted by our incredible graduate students who are vital to our school's mission to move humanity forward through research, education and preparing the engineering leaders of tomorrow. Their drive and dedication inspire and exemplify what it means to be a Boilermaker engineer.

All the best,

Rao S. Govindaraju
Bowen Engineering Head of Civil and Construction Engineering and Christopher B. and Susan S. Burke Distinguished Professor of Civil Engineering

IN THIS ISSUE:

ON THE COVER

Technology that uses a photo to pinpoint your location is just one of the many ways Lyles School faculty are harnessing the power of artificial intelligence.

CCE Impact is published biannually for alumni and friends of the Lyles School of Civil and Construction Engineering. We welcome your comments, opinions and questions.

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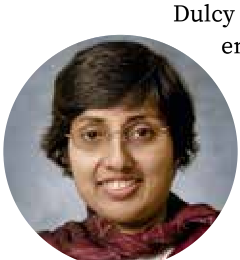
NEWS & EVENTS

CONGRATULATIONS GRADUATES!

Congratulations to our graduating class of 2024! In May, we saw more than 150 graduate and undergraduate students earn their degrees. We wish our newest alumni class the very best and look forward to learning of their future accomplishments.

PROF. ABRAHAM NAMED INAUGURAL ASCE WOMEN IN CONSTRUCTION AWARDEE



Dulcy Abraham, professor of civil and construction engineering, was named the inaugural recipient of the American Society of Civil Engineers' Construction Institute Advancement of Women in Construction Award. This award was given to Abraham for her excellence as a construction academic in the areas of teaching, research and service, and demonstrated support, guidance, mentoring and promotion of growth opportunities for the advancement of women in the construction profession.

PROF. LU EARNS GOLD AT THE EDISON AWARDS

Luna Lu, the Reilly Professor of Civil Engineering, has been recognized as a gold winner of an Edison Award in the critical human infrastructure category for leading the development of sensor technology that could help reduce time and money spent on the construction and repair of concrete highway pavements and other structures. The Edison Awards, considered the "Oscars of innovation," are given annually to "recognize the persistence and excellence that also characterized Thomas Edison's work."

INTRODUCING

THE LYLES SCHOOL

OF CIVIL AND CONSTRUCTION ENGINEERING

New opportunities and a greater knowledge network are in store for the Lyles School of Civil and Construction Engineering.

As of July 1, the Lyles School of Civil Engineering and the Division of Construction Engineering and Management have merged. The merger marks a new era for the school as it aims to provide its students with greater industry connections and more internship and co-op opportunities.

"With civil engineering and construction engineering degrees offered under one umbrella, each program will grow student enrollments by combining and leveraging each other's strengths and address an ever-growing list of industry needs," said Arvind Raman, the John A. Edwardson Dean of the College of Engineering.

The merger better positions the school and its students to meet the increasing need for qualified engineers in the civil and construction fields in the United States. The country's bipartisan infrastructure law, passed in 2021, directs $1.2 trillion in federal funds toward transportation, energy and climate infrastructure projects.

"This is an incredibly exciting time at Purdue that will see our students better prepared to become the engineering leaders of tomorrow," said Rao S. Govindaraju, the Bowen Engineering Head of Civil Engineering and the Burke Distinguished Professor of Civil Engineering. "We are always striving to provide our students with the best education and skills possible and this merger aligns perfectly with that goal"

The Lyles School will be better positioned to offer new programs and opportunities, such as certificate programs and professional concentrations, at both the graduate and undergraduate levels more effectively and efficiently. With the expansion in educational and experiential opportunities, the Lyles School is poised to remain at the forefront of preparing the engineering leaders of tomorrow.

This engagement will also launch new professional master's courses focused on smart cities and urban informatics to upskill the civil and construction engineering workforce on new AI methods, data science and resilience engineering, and to adopt real-world case studies from relevant engineering programs using the city of Indianapolis as a living lab.

INDOOR AIR POLLUTION

Study finds gas stoves emit more nano-sized particles than car exhaust

Cooking on your gas stove can emit more nano-sized particles into the air than vehicles that run on gas or diesel, possibly increasing your risk of developing asthma or other respiratory illnesses, a new Purdue University study has found.

"Combustion remains a source of air pollution across the world, both indoors and outdoors," said Brandon Boor, associate professor of civil and construction engineering. "We found that cooking on your gas stove produces large amounts of small nanoparticles that get into your respiratory system and deposit efficiently."

Boor's study focused on tiny airborne nanoparticles, called nanocluster aerosols, that are only 1-3 nanometers in diameter — which is just the right size for reaching certain parts of the respiratory system and spreading to other organs.

"These super tiny nanoparticles are so small that you're not able to see them. They're not like dust particles that you would see floating in the air," Boor said. "After observing such high concentrations of nanocluster aerosols during gas cooking, we can't ignore these nano-sized particles anymore."

High-resolution air quality data collected from state-of-the-art aerosol instruments allowed the researchers to compare their findings with known outdoor air pollution levels, which are more regulated and understood than indoor air pollution. They found that as many as 10 quadrillion nanocluster aerosol particles could be emitted per kilogram of cooking fuel — matching or exceeding those produced from vehicles with internal combustion engines. This would mean that adults and children could be breathing in 10-100 times more nanocluster aerosol particles from cooking on a gas stove indoors than they would from car exhaust while standing on a busy street.

"What we've learned is that models could not accurately capture the transformations of particles this small in size," said PhD student Satya Patra, who collected data for this research at the school's tiny house lab.

The models showed that nanocluster aerosol particles are very persistent in their journey from the gas stove to the rest of the house. Trillions of these particles were emitted within just 20 minutes of boiling water or making grilled cheese sandwiches or buttermilk pancakes on a gas stove.

Even though many particles rapidly diffused to other surfaces, the models indicated that approximately 10 billion to 1 trillion particles could deposit into an adult's head airways and tracheobronchial region of the lungs. These doses, normalized by body weight, would be even higher for children — the smaller the human, the more concentrated the dose.

The nanocluster aerosols coming from gas combustion could easily mix with larger particles entering the air from butter, oil or whatever else is cooking on the gas stove, resulting in new particles with their own unique behaviors.

This study was supported by a National Science Foundation CAREER award to Boor. Additional financial support was provided by the Alfred P. Sloan Foundation's Chemistry of Indoor Environments program through an interdisciplinary collaboration with Indiana University.

Brandon Boor, associate professor of civil and construction engineering

Sam Labi, professor of civil and construction engineering and faculty lead for Purdue AI Racing, with the team's autonomous race car at the Las Vegas Motor Speedway in January.

THE RACE IS ON

Autonomous vehicle team continues to rev up the competition

From being stuck at zero in previous years to breaking the 100 mph mark in January, Purdue's autonomous vehicle racing team has made impressive strides over the years.

The Black and Gold Racing team was formed in 2021 when the inaugural Indy Autonomous Challenge encouraged institutions worldwide to develop and test new generations of software to operate fully autonomous race cars.

That October, 21 universities from nine countries competed at the Indianapolis Motor Speedway where Germany's Technical University of Munich took the top prize. Purdue's team encountered challenges that have plagued the team at similar competitions until recently.

Sam Labi, professor of civil and construction engineering, became the team's lead faculty advisor in fall 2022. Labi is director of the campus branch of the Center for Connected and Automated Transportation. The core team at that time was comprised of volunteer students from various disciplines, including the Purdue Polytechnic Institute, electrical and computer engineering, aeronautical and astronautical engineering and civil and construction engineering.

"I was drawn to this initiative because it brings together a global community of engineers to address a complex challenge." Labi said. "Additionally, in building future highways, our civil and construction engineering students must learn to develop new road design philosophies that account for the prevailing levels of vehicle automation."

In fall 2023, persistent efforts by Labi led to funding from Arvind Raman, dean of the College of Engineering which fueled several changes including expanding and restructuring the team and a renaming to Purdue AI Racing.

After exhibiting significant progress, Purdue was invited to partake in the January 2024 race in Las Vegas. In a bid to qualify for the main event, the Purdue vehicle reached a record 103 mph but suffered a side-crash and thus exited the competition.

"Las Vegas was a valuable experience and motivated the team to seek greater heights," said CCE graduate student Richard Ajagu. "Our leaps in such a short period were unprecedented. As our team grew in size and experience, we remained focused on winning."

Daniel Williams, professor of engineering practice, became the director of Purdue AI Racing in spring 2024. The team will compete in the IAC at the Indianapolis Motor Speedway again this fall.

ELECTRIFIED HIGHWAY

Technology wirelessly charges electric vehicles while driving

Purdue University engineers John Haddock (left), Nadia Gkritza, Dionysios Aliprantis and Steve Pekarek stand in the lab where they are testing technology they designed to enable electric vehicles of all classes to receive power from the road.

This spring marked the groundbreaking for a giant leap forward in electric vehicle viability in the United States.

At the "Crossroads of America," Purdue University engineers and the Indiana Department of Transportation (INDOT) are partnering to design and build infrastructure that allows electric vehicles ranging from semitrailers to passenger cars to wirelessly charge while driving on highways. Construction is in progress on a quarter-mile test bed in West Lafayette that the team will use for testing how well a patent-pending system designed by Purdue engineers can provide power to a heavy-duty electric truck traveling at highway speeds.

An electric truck provided by Indiana-based company Cummins Inc. will drive over the test bed as part of a pilot program planned to start next year with the hope to electrify a section of an Indiana interstate in the next four to five years.

"We are Purdue University, where the difficult is done today and the impossible takes a bit longer," said John Haddock, professor of civil and construction engineering.

Purdue civil engineering PhD students Oscar Moncada (MSCE '23) and Gaia Cervini (MSCE '21) will conduct a comprehensive thermal analysis of the new highway segment, significantly contributing to the advancement of this transformative technology.

The Purdue-designed wireless charging system is intended to work at power levels much higher than what has been demonstrated in the U.S. thus far. By accommodating the higher power needs for heavy-duty vehicles, the design is also able to support the lower power needs of other vehicle classes.

"We're developing a system that has the power to charge semitrailers as they move 65 miles per hour down the road," Haddock said.

An electrified highway in Indiana would serve much of the nation's traffic. Eighty percent of the U.S. can be reached within a day's drive from the state's pass-through highways. Building electrified highways with heavy-duty trucks in mind would maximize both greenhouse gas reductions and the economic feasibility of developing infrastructure for EVs.

"The so-called 'middle mile' of the supply chain, which refers to heavy-duty trucks carrying goods from one major location to another, is the most challenging part of the transportation sector to decarbonize," said Nadia Gkritza, professor of civil and construction engineering and agricultural and biological engineering.

The wireless charging system includes transmitter coils that would be installed in specially dedicated lanes underneath normal concrete pavement to send power to receiver coils attached to the underside of a vehicle.

The researchers anticipate that it may be 20 to 30 years before EVs can receive the full power they need while driving at highway speeds. It is up to EV manufacturers to incorporate receiver coils into their vehicles.

Construction is in progress on a quarter-mile test bed on U.S. Highway 231 and U.S. Highway 52 in West Lafayette that the team will use for testing how well a patent-pending system designed by Purdue engineers can provide power to a heavy-duty electric truck traveling at highway speeds.

Using ChatGPT, this autonomous vehicle learns passenger preferences via verbal commands and makes performance decisions accordingly.

BUILDING A BETTER FUTURE

Five ways faculty are harnessing the power of artificial intelligence

We're not living in the age of "The Jetsons" just yet, but by the time we reach 2062 — the futuristic year in which the cartoon sitcom was set — we might be.

As they have for millennia, civil and construction engineers will play a key role in shaping the conception and design of infrastructures and systems to sustain our civilization. The integration of artificial intelligence is already impacting the industry by powering solutions that enhance efficiency, safety and sustainability.

At Purdue, faculty in the Lyles School of Civil and Construction Engineering are applying machine learning, data mining and pattern and image recognition to solve problems and improve the needs of society.

Read on to learn how some of our brightest minds are harnessing the power of AI technology to build a better future.

Ziran Wang, assistant professor of civil and construction engineering (center), with his research team and their autonomous vehicle that processes commands using ChatGPT.

A CAR THAT CAN PRACTICALLY READ YOUR MIND

Imagine climbing into your autonomous vehicle, muttering that you should have woken up 20 minutes earlier. The car interprets this information as "I am running late" and therefore drives a bit more aggressively on the way to your destination.

Ziran Wang, an assistant professor of civil and construction engineering, and a team of researchers in the Purdue Digital Twin Lab are collaborating with Toyota Motor North America to develop a first-of-its-kind autonomous driving system that leverages large language models to understand the implicit and personalized needs of its passengers.

Using ChatGPT, the autonomous vehicle learns passenger preferences via verbal commands and makes performance decisions accordingly. Not only can the car tell when you're in a hurry, it also ascertains your preferred driving style, be it sporty or cautious. This is different from direct human input in today's vehicles, where a driver can press a button to change from eco mode to sport mode. It's using AI to interpret several preference categories to intuitively respond to a passenger's wants and needs.

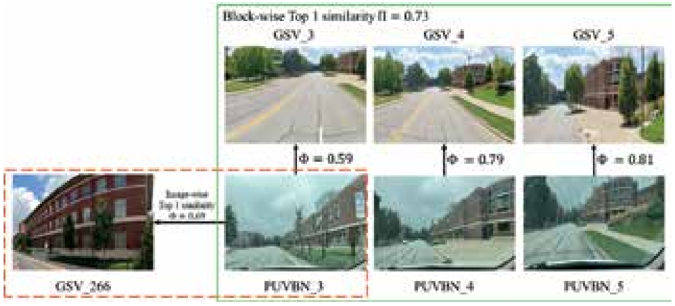
"If you're riding along on the freeway and see another vehicle performing recklessly, stating 'that car is crazy!' will prompt ChatGPT to reason that you'd like the autonomous vehicle to change lanes to prevent a collision," Ziran said.

It can help snag a better parking spot, too.

"The first time you drive to a stadium, the vehicle will navigate to the parking spot nearest the entrance," Ziran said. "But next time, ChatGPT learns your preference is to leave a bit early so you don't get stuck in parking lot traffic. The vehicle will adapt and choose a parking spot closer to the parking lot exit."

Even though commonplace autonomous vehicles may still be a way off, Ziran said the ChatGPT model can be applied to existing advanced driver-assistance systems found in newer cars.

"Driver assistance systems such as adaptive cruise control can benefit from ChatGPT," Ziran said. "Drivers may prefer larger or smaller gaps based on driving preference, current speed or road conditions, and knowing that information, the adaptive cruise control can respond accordingly. Large language models can help facilitate human-autonomy teaming and improve the system's performance for the driver."



Jie Shan, professor of civil and construction engineering, led a team of researchers in developing a technology that mines photographic data from Google Street View to pinpoint a user's location.

Using data gathered from other rivers, Venkatesh Merwade, professor of civil and construction engineering, developed a deep learning model to extrapolate the riverbed geometry of unmapped sections of the Brazos River.

TECHNOLOGY THAT USES A PHOTO TO PINPOINT YOUR LOCATION

Poor cell service is a common issue in densely populated areas such as large cities. That can be problematic for tourists relying on their smartphone's map application to navigate the streets. Instead of a precise location, the app might display a large circle encompassing several city blocks of the neighborhood. Imagine a vehicle equipped with sensors that snap photos of your surroundings to identify exactly where you are.

Jie Shan, professor of civil and construction engineering, and a team of researchers are developing a technology that mines photographic data from Google Street View to match images of a user's surroundings. The technology operates independent of GPS signals to match the live photo to a database of images from Google Street View.

Not only can the technology identify your location, it also can determine your orientation based on which direction the sensor is pointing.

"Navigational positioning with emerging technologies such as autonomous driving is very important," Shan said. "There is so much public information available, including Google Street View, aerospace images, digital terrain and city models. This technology leverages AI to track specific features on those images to identify a precise location."

The researchers used AI technology to classify objects within live images, such as trees, roads, buildings and windows. They also applied the same algorithm to the database of Google Street View images. Photos were then matched to the image database using geometric and spectral characteristics to train the model to identify similar patterns. The researchers tested their method with images captured by both smartphones and drones. The technology developed by Shan and his team could one day be used to help automated drones navigate to their destinations.

"Civil and construction engineering isn't only about building the infrastructure, it's also about monitoring what's been built and using those systems efficiently," Shan said. "We must have precise measurements to assess the systems in place, and that's where AI comes in. On the one hand, we sense the environment, but then we should be able to close the loop and use the data that's been collected for the benefit of society."

A BETTER WAY TO MAP WATERWAYS IN 3D

Flood events rose nearly 29% in the United States in 2023, leading to $7 billion in estimated damages according to the National Centers for Environmental Information. Understanding the riverbed geometry of specific waterways is crucial to developing water flow models and making recommendations for how to staunch potential floods.

Traditional methods of river mapping are time consuming and not feasible for large sections so data only exists for certain portions of many major rivers in the U.S. Venkatesh Merwade, professor of civil and construction engineering, and a team of researchers have developed a deep learning model that can extrapolate the riverbed geometry of unmapped sections based on the detailed geometry data available from other sections combined with aerial maps.

"We, and many others, have attempted to fill in these gaps using conceptual methods and physics-based methods, but our deep learning model provides results that are more accurate than what has been estimated with other methods," Merwade said. "The eventual goal is to develop a model that can be applied to any river where data does not yet exist."

The model has been implemented and tested for some areas of the Mississippi River as well as the Brazos River in Texas. Accurately mapping a river's three-dimensional geometry by measuring its width, centerline, curvature, slope and other properties allows scientists to conduct detailed studies about flooding or contaminant transport.

PhD candidate Chung-Yuan Liang contributed to the research, some of which is funded by the National Science Foundation. In collaboration with the University of Iowa, Merwade developed RIMORPHIS, a publicly available research portal for river morphology studies. For future projects, Merwade plans to leverage the resources available in the Rosen Center for Advanced Computing at Purdue.

"The traditional methods of mapping a few kilometers of a river haven't changed in decades," Merwade said. "It's as challenging and expensive as it was 20 years ago. We need to develop ways of making this data more readily available so we can better understand our rivers and make more accurate flood predictions. Using tools based on advanced statistical analysis to obtain accurate river morphology information is very exciting."

A research team led by Satish Ukkusuri, the Reilly Professor of Civil Engineering, developed AI toolkits to conduct predictive analytics to determine EV demand and travel patterns to inform charging infrastructure needs.

PREDICTING THE NEED FOR EV INFRASTRUCTURE

The demand for electric vehicles in the United States is growing. In 2024, it is estimated that one in nine cars sold in the U.S. will be electric.

While electric vehicles boast many attributes, including savings on fuel costs, energy efficiency, lower pollution and cheaper maintenance, there are still some disadvantages to owning an electric car. One of the primary drawbacks? The limited availability of charging infrastructure makes it challenging to recharge an electric car while on the go.

"It's a bit of the chicken and the egg problem," said Satish Ukkusuri, the Reilly Professor of Civil Engineering. "There is a growing demand for electric vehicles, but it is important to understand where the demand is coming from so charging infrastructure can be built in the correct locations. If we only accommodate electric vehicles in urban environments, there would be little incentive for rural residents to buy electric vehicles because they don't have easy access to charging stations."

Using anonymized high resolution cellphone data, Ukkusuri and his research team developed a machine learning model to identify electric vehicles by examining underlying driving characteristics such as a vehicle's acceleration and speed as well as stops at charging stations. The team then analyzes traffic patterns to identify where electric vehicle users travel, what activities they participate in during the day and how frequently they visit charging stations.

The research team, which includes PhD students Xiaowei Chen, Omar Hamim and Zengxiang Lei, has developed AI toolkits to conduct predictive analytics to determine EV demand and travel patterns and compare that data with existing charging infrastructure needs. Using this information, the team can make recommendations to the Indiana Department of Transportation, which is funding the research, about EV travel corridors, where charging stations may be needed in the future and inform EV equity planning to fill gaps in the existing infrastructure.

"There's an expected shift in purchasing behavior of electric vehicles in Indiana and throughout the Midwest," Ukkusuri said. "We want to be a catalyst for this change by identifying the infrastructure planning needed to support electric vehicles and make it convenient for people to make the EV transition using AI based data driven decision support."

Software developed by Mohammad Jahanshahi, associate professor of civil and construction engineering, can identify specific frames of time-lapse video where certain activities are being conducted at a construction site.

QUALITY CONTROL FOR ROAD CONSTRUCTION

Roads are a critical part of the nation's transportation system. When new roads are built or old roads are repaired, the contractor is expected to follow specifications for construction outlined by local, state or federal governmental agencies.

However, sometimes corners are cut, and not always intentionally. Currently, transportation officials don't have an efficient means of ensuring work is being completed according to specifications — and that's a problem. It is imperative that these regulations are strictly followed to reduce the risk of accidents and make transportation smoother and more efficient.

Mohammad Jahanshahi, associate professor of civil and construction engineering, and PhD students Malleswari Kachireddy and Nikkhil Vijaya Sankar (BSECE '21), have developed software that uses computer vision and advanced machine learning to search hours of time-lapse video and identify frames where specific work activities are being done. Transportation officials can then review the identified relevant frames, without scrubbing through weeks, or even months, of video. The technology was developed in partnership with the Indiana Department of Transportation, which provided funding for the project.

"Working with INDOT, we focused a specific type of construction — the building of mechanically stabilized earth walls," Jahanshahi said. "If regulations are not followed, these structures can be deficient and lead to failure. Our tool allows the INDOT staff to perform quality control without being on site for the duration of the project."

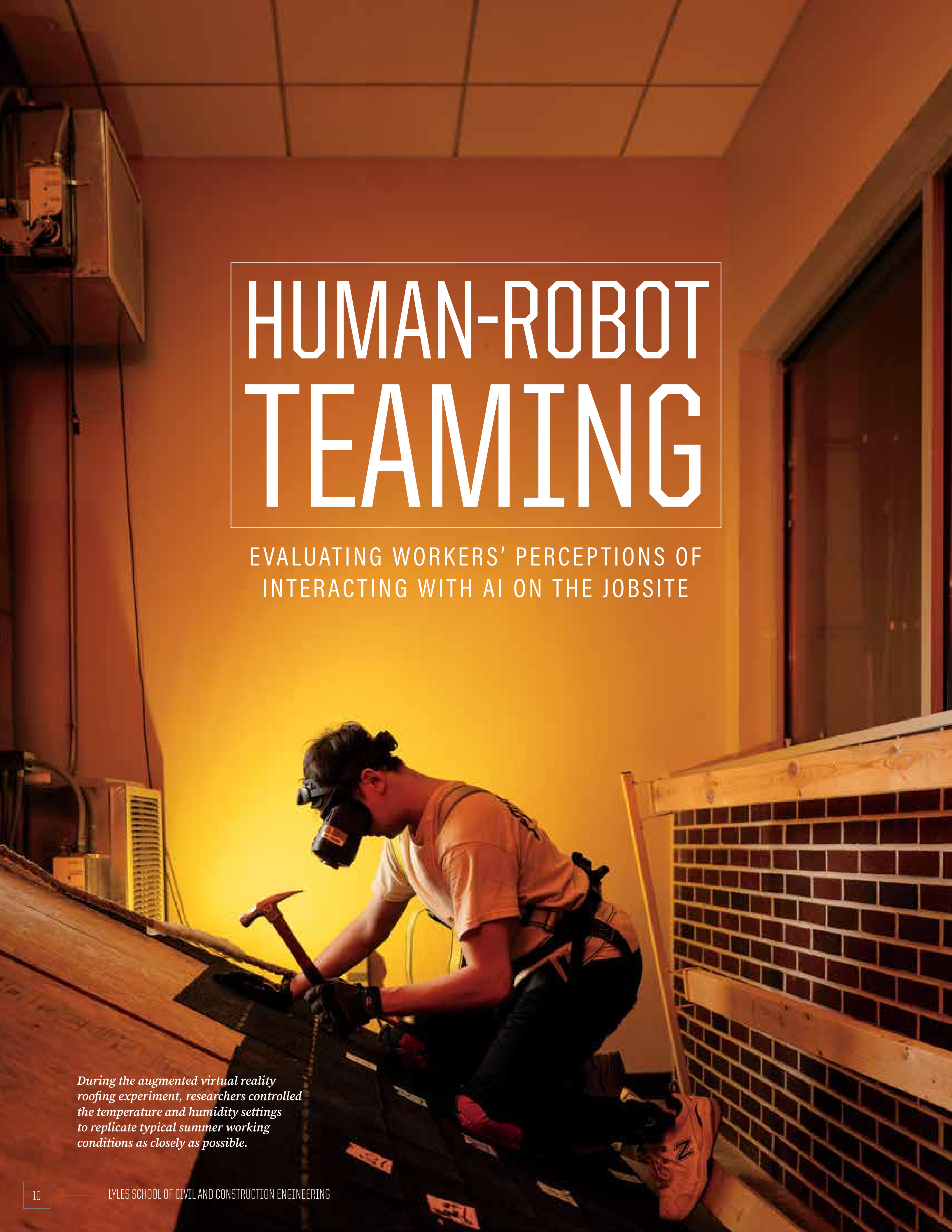
The software was trained to identify four activities in the MSE wall construction process: backfilling, compaction, strap installation and MSE panel installation. The software can be adapted in future applications to identify other activities specific to a project.

"Our system conducts a comprehensive analysis," Jahanshahi said. "Not only can it identify equipment at a construction site, but it can also track those objects to determine how the work is being done. It can parse information from a complex environment where multiple activities may be completed simultaneously.

"The opportunities for application of AI are limitless. But the technology only enhances human decision-making. You cannot exclude the human from the loop."

HUMAN-ROBOT TEAMING

EVALUATING WORKERS' PERCEPTIONS OF INTERACTING WITH AI ON THE JOBSITE



During the augmented virtual reality roofing experiment, researchers controlled the temperature and humidity settings to replicate typical summer working conditions as closely as possible.

Artificial intelligence and machine learning have already begun to transform the construction site. Robotic bricklaying machines can place up to 3,000 bricks per day. AI-powered cameras and sensors can alert the crew of potential safety hazards. Drones can deliver tools and materials on site.

But there's still a human component to human-robot teaming and not much research has been done to evaluate how an individual's reaction to technology affects their ability to interact with it. Woei-Chyi Chang, a PhD candidate and graduate researcher working with Sogand Hasanzadeh, assistant professor of civil and construction engineering, sought to better understand the worker perspective when interacting with AI on the job through multidisciplinary research converging at the nexus of civil engineering, AI and human factors.

"We expect to see a lot of different AI technologies incorporated in future worksites," said Chang. "Through this research, I wanted to evaluate three primary components essential for successful human-robot teaming: trust, communication and safety."

The researchers created two different environments to simulate future job sites and evaluate how workers react to human-robot teaming. In a mixed-reality bricklaying scenario, participants donned a virtual reality (VR) headset that depicted a large building construction project. In the immersive environment, participants held physical tools while moving around the space, interacting with a bricklaying robot and virtual bricks. Periodically, a virtual drone would fly into the scene to deliver a fresh bucket of mortar or communicate messages and change orders.

"The mixed reality environment contains passive haptics, which are physical objects in the space that represent virtual objects participants see with the VR headset," Hasanzadeh said. "Combined, these elements create an immersive environment of the construction site. When the drone approaches the worker, they can hear the blades spinning very fast."

To determine whether a malfunction of the technology would affect workers' trust, Chang programmed the virtual drone to fly into the participant's body. Although participants were not physically harmed, the VR environment created the perception that the drone made contact.

"It can take time for workers to build their trust with AI, but once that trust is lost due to malfunction of the system, how long will it take to reestablish their trust?" Hasanzadeh said. "To achieve a safe, inclusive construction site of the future, AI systems must be able to anticipate, track and predict all types of worker behavior to team effectively and prevent jobsite injuries."

The second scenario simulated a residential roofing job where participants perched on a physical sloped platform meant to replicate roof decking. For this augmented virtual reality experiment, participants wore a harness, just as they would on an actual job site, and interacted with a physical hammer to install actual asphalt shingles.

An extended reality headset displays a full virtual environment that extends beyond the physical platform, while still allowing the individual to see the roof decking, materials and their own hands in the physical world. Once again, the participants interacted with a virtual drone that inspected their

The worker-AI collaborative bricklaying experiment necessitates workers' interaction with a bricklaying robot, drones, and AI-assistant under various conditions, such as technology malfunction, time pressure, and multitasking.

performance, delivered messages or asked questions regarding work progress.

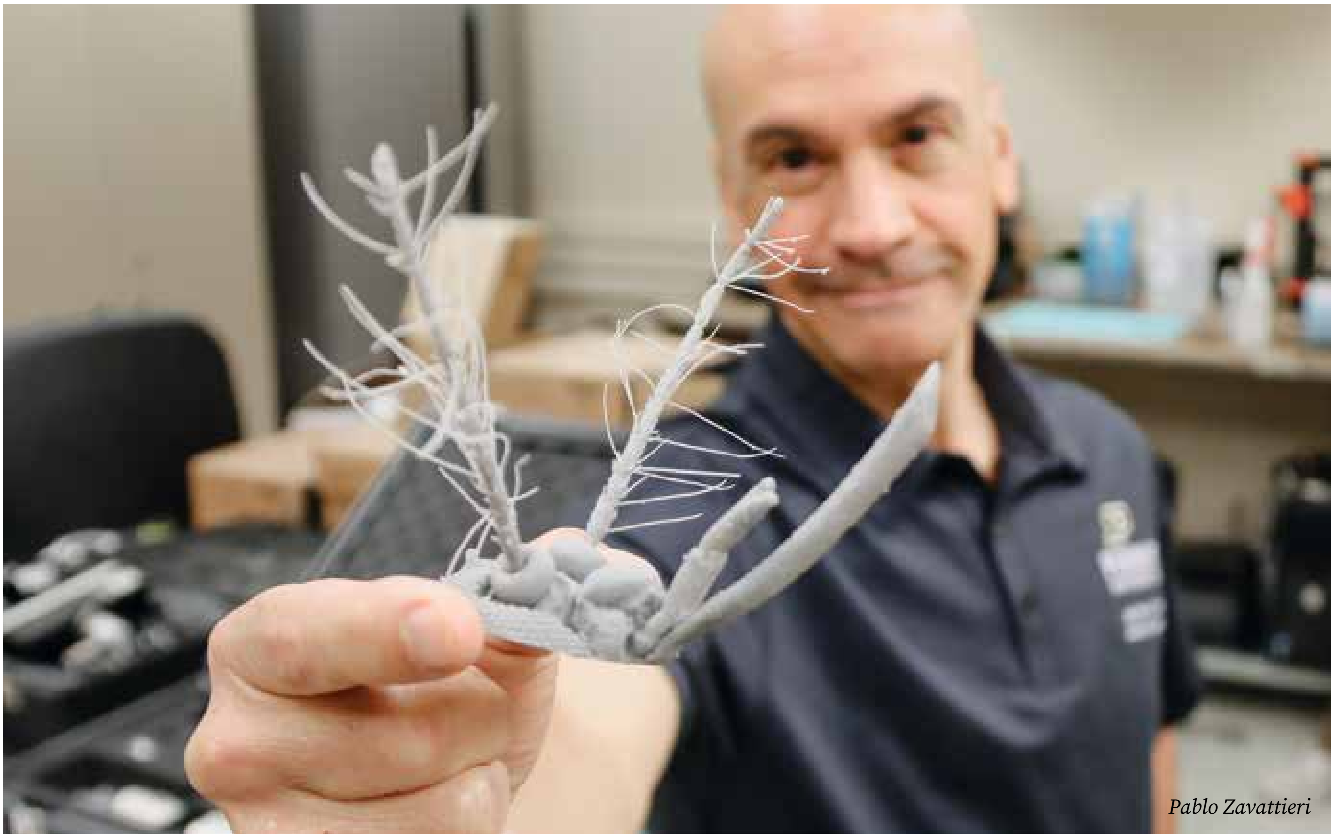
In the roofing experiment, Chang and Shiva Pooladvand (PhD CE'24) controlled the temperature and humidity settings to replicate typical summer working conditions as closely as possible. The chamber used for the roofing environment, located in Herrick Laboratories, registered a heat index of 107 degrees.

The researchers collected subjective data from participants, asking them questions to evaluate their level of trust and acceptance of technology. They also collected objective data through eye tracking, brain activation, heart rate and skin conductance, which is a measure of nervous system arousal in response to stimuli. They analyzed the data to determine how trust, communication and safety affect worker acceptance of technology.

"Construction is already a physically and mentally demanding field," Chang said. "The demands of productivity can create high pressure situations where workers over-trust technology or do not pay enough attention to it. When that technology malfunctions, it becomes problematic and can cause safety risks. It is important for workers to have effortless communication with AI so they are not overtaxed."

The next step is to devise strategies on how to design construction technology in a manner that helps human workers successfully interact with AI on the job site. Despite advances in technology, Hasanzadeh doesn't envision a future where AI takes over the construction industry entirely.

"The construction environment is very complicated and dynamic," Hasanzadeh said. "AI can help improve safety and enhance efficiency, but it cannot work alone. We cannot remove humans from the process. Robots can ease some of the physical demands of a construction site, but for rational problem solving with changing variables, we need human input. Workers should not be the passive recipients of these technologies, they should be active members of a team."



Pablo Zavattieri

BIO-INSPIRED DESIGN

Mosquito antennae may hold secrets to developing vibration sensors

One of nature's most disliked creatures may very well unlock a breakthrough in disaster response.

A Purdue University multidisciplinary research team — led by Pablo Zavattieri, the Jerry M. and Lynda T. Engelhardt Professor in Civil Engineering — is recreating mosquito antennae to better study their sensitivity to vibrations. Should the research prove fruitful, it could lead to improvements in monitoring and detecting natural disasters such as earthquakes and tsunamis.

"We're still in the early stages but we're pretty optimistic that we'll at least learn a great deal," Zavattieri said. "Taking inspiration from nature and using it to advance scientific research has been a core feature of engineering since the very beginning."

Despite lacking traditional ears, mosquitoes rely on their antennae to navigate the auditory landscape, homing in on crucial sounds amidst the background noise of their own wingbeats. Through analysis of their antennal features — particularly the arrangement and morphology of sensory hairs — civil and construction engineering PhD student and team researcher Phani Saketh (MSCE '23) said they have already gained "profound insights into how these adaptations enhance the auditory sensitivity and selective response to environmental cues."

"Mosquitoes are able to detect frequencies we weren't even aware of," Saketh said. "We're not entirely sure whether the mosquitoes are aware they are sensing these frequencies, or if they do not need to do so. Either way, there appears to be potential to detect frequencies that the mosquitoes do not actively employ."

In terms of societal impact, insights from mosquito antennae could also inform the development of smart noise-canceling materials, Zavattieri said. These materials, potentially incorporating microfluidic channels or tunable metamaterials, could be used to create soundproofing panels for buildings, noise-canceling headphones or even acoustic cloaking devices.

"Imagine urban environments equipped with bio-inspired sensors, akin to 'big ears,' capable of discerning specific sounds amid the hustle and bustle of city life," Zavattieri said. "In times of crisis — such as earthquakes or other disasters — these sensors become invaluable, swiftly detecting faint signals of distress and guiding rescue efforts to those in need."

Zavattieri said his team is currently focused on recreating the antennae through 3D printing, using different materials and at varying sizes for frequency testing. He expects to publish their first report in the fall of 2024.

ALUMNA SPOTLIGHT

ODEN OFF THE COURT

AND IN THE FIELD

From dominating the basketball court to designing the Atlanta skylines, Lyles School of Civil and Construction Engineering alumna Dominique Oden says she drew on inspiration and determination to be where she is today.

Growing up in Atlanta, Oden (BSCE ’20, MSCE ’21) said her interest in civil engineering was sparked by her uncle’s influence.

“He was an architect and I found what he did to be really interesting,” Oden said. “I remember asking him what I should do to be in his field and pretty much the first thing he told me was ‘study to be a civil engineer instead.’ From there, I looked to which schools had the best civil engineering programs and Purdue was at the top of all the lists.”

There was one other quality Oden said she was looking for in her university of choice — a strong women’s basketball program. Oden was a talented shooting guard and she wanted to find a place that would allow her to pursue both of her passions at once.

“I’m very happy I chose Purdue; it was exactly what I was looking for,” Oden said. “And learning time management skills as a student-athlete really helped me balance myself”

While studying to earn her bachelor’s degree in civil engineering, Oden was the starting shooting guard on the women’s basketball team from 2016 until 2020. Over the course of her college career, she started in 132 games and won several Big Ten honorable mention awards.

After earning her master’s degree at Purdue, Oden moved back to Atlanta and is currently working in her second year as a structural design engineer at Davis & Church.

“I’m finishing up on a project in Atlanta that was my first major project when I started working here two and a half years ago,” Oden said. “We’re toward the end of the construction phase and it’s so exciting to watch nothing turn into to full buildings.”

Oden stressed the importance of staying current as a civil engineer and how the EIT license is something that civil students can obtain before they graduate. Another piece of advice Oden offered to current civil and construction engineering students is to utilize the wealth of knowledge and experience available.

“I really wish I had used my professors a bit more in terms of mentorship, and their connections,” Oden said. “They were all so knowledgeable and willing to offer guidance.”

Currently, Oden is spending her free time coaching basketball and learning Krav Maga, an Israeli martial art. “Finding the time, that balance between your work life and your personal time, it’s super important.”

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