Fall 2021

INSPIRE Newsletter Fall 2021

Missouri University of Science and Technology. INSPIRE - University Transportation Center

TIER 1 UNIVERSITY TRANSPORTATION CENTER (UTC)

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INSPIRE

INSPECTING AND PRESERVING INFRASTRUCTURE THROUGH ROBOTIC EXPLORATION

VOL. 5 | ISSUE 2 | FALL

INSPIRE-UTC Biannual Publication

In this issue:

Awarded in December of 2016 by the U.S. Department of Transportation, the five-year **INSPIRE UTC** is a Tier 1 University Transportation Center with a research priority of preserving the existing transportation system as part of the UTC Program (https://www.transportation.gov/utc/2016-utc-grantees) that was authorized under the Fixing America's Surface Transportation Act.

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Director's Message

Greetings colleagues and friends! Since our last newsletter, the INSPIRE University Transportation Center (UTC) has achieved over 13,000 members on our email listserv and has hosted various virtual and in-person events for additional interest and outreach.

The INSPIRE UTC continues to focus on ways to engage new and existing members of interest in transportation and infrastructure research. In this edition, we will highlight the development and launching of a new video series called *Frontiers in Infrastructure Research and Education* simply called a *FIRE* video series. The objectives of this video series are to provide the INSPIRE members, the research community, and the public with INSPIRE UTC's exploration on the use of Industry 4.0 technologies, vision on technical challenges, and solutions to the challenges in transportation and infrastructure research.

This edition of newsletter will feature three articles focusing on nondestructive evaluation (NDE) technologies that are suitable for robot-assisted operation and application by INSPIRE UTC researchers. These studies include (1) Eddy Current Sensor Integrated Robotic Solution for Steel Structure Inspection by Dr. Hung La from University of Nevada at Reno, (2) Autonomous Ultrasonic Thickness Measurement on Steel Bridge Members by a Magnet-Wheeled Mobile Robot by Dr. Yang Wang from Georgia Tech and (3) Robot-based Ground Penetrating Radar (GPR) Data Collection and 3D Reconstruction by Dr. Jizhong Xiao from the City College of New York.

This issue also highlights both graduate and undergraduate students. Three graduate students who are main contributors to three INSPIRE UTC projects received the top poster competition awards during the 2021 INSPIRE UTC annual meeting. Additional five graduate students participating in the poster competition are introduced to demonstrate the nature of interdisciplinary work at the INSPIRE UTC. Additionally, seven undergraduates in civil, computer, electrical and mechanical engineering participate in various technical and administrative activities at the INSPIRE UTC. They are not only contributors to the technical tasks of INSPIRE UTC projects, but also future workforce in emerging careers on the use of Industry 4.0 technologies in civil infrastructure.

Other highlights will include the annual meeting events, cross-disciplinary training with members of Chi Epsilon, and undergraduate research students at the INSPIRE UTC. This edition will also highlight the Boy Scout Invention Jamboree, Jackling Introduction to Engineering and Kaleidoscope Discovery Center's FIRST Lego League and Missouri Future City Competition.

The Center continues to host webinars on a quarterly basis, engaging attendees worldwide on infrastructure and transportation related topics with over 400 registrants each. The webinars serve to highlight collaborative opportunities and to showcase on-going research being conducted at the INSPIRE UTC.

We hope you enjoy the featured articles and exciting news of INSPIRE UTC and invite you to visit our website at https://inspire-utc.mst.edu for additional information about upcoming events and webinars.

Genda Chen, Ph.D., P.E., F. ASCE, F. SEI, F. ISHMII

Director, INSPIRE University Transportation Center
Director, Center for Intelligent Infrastructure

NEWS

2021 INSPIRE UTC Annual Meeting

The INSPIRE UTC hosted a virtual annual meeting on August 10-11, 2021. Activities included technical research presentations by major university member principal investigators and an INSPIRE UTC executive business meeting. Highlighted topics included were updates on recent developments with the seven-state pooled-fund study and a virtual graduate poster session.

The 2021 Annual Meeting included the following presentations:

SENSING AND NONDESTRUCTIVE EVALUATION

AUTONOMOUS ULTRASONIC THICKNESS MEASUREMENT BY A MAGNET-WHEELED ROBOT, Dr. Yang Wang, Georgia Institute of Technology

HEALTH INSPECTION OF CONCRETE PAVEMENT AND BRIDGE MEMBERS EXPOSED TO FREEZE-THAW SERVICE ENVIRONMENTS, Dr. Hongyan Ma, Missouri S&T

PROBABILITY OF DETECTION IN CORROSION MONITORING WITH FE-C COATED LPFG SENSORS, Dr. Genda Chen, Missouri S&T

INSPECTION AND MAINTENANCE

SMART SOUNDING SYSTEM FOR AUTONOMOUS EVALUATION OF CONCRETE AND METALLIC STRUCTURES, Dr. Anil Agrawal, The City College of New York

AUTONOMOUS SYSTEMS

BRIDGE INSPECTION ROBOT DEPLOYMENT SYSTEMS (BIRDS), Dr. Bo Shang, Missouri S&T

NONDESTRUCTIVE DATA DRIVEN MOTION PLANNING FOR INSPECTION ROBOTS, Dr. Hung La, University of Nevada, Reno

A FIELD DEPLOYABLE WALL-CLIMBING ROBOT FOR BRIDGE INSPECTION USING VISION AND IMPACT SOUNDING TECHNIQUES, Dr. Jizhong Xiao, The City College of New York

AUGMENTING BRIDGE INSPECTION WITH AUGMENTED REALITY AND HAPTICS-BASED AERIAL MANIPULATION, Dr. Paul Oh, University of Nevada, Las Vegas

ROBOT-ASSISTED UNDERWATER ACOUSTIC IMAGING FOR BRIDGE SCOUR EVALUATION, Dr. Liujun Li, Missouri S&T

RETROFIT AND RESILIENCE

DATA-DRIVEN RISK-INFORMED BRIDGE ASSET MANAGEMENT AND PRIORITIZATION ACROSS TRANSPORTATION NETWORKS, Dr. Iris Tien, Georgia Institute of Technology

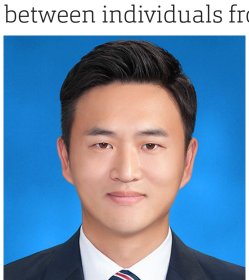
WORKFORCE DEVELOPMENT

SIMULATION TRAINING TO WORK WITH BRIDGE INSPECTION ROBOTS, Dr. Sushil Louis, University of Nevada, Reno

AN INTERACTIVE SYSTEM FOR TRAINING AND ASSISTING BRIDGE INSPECTORS IN INSPECTION VIDEO DATA ANALYTICS, Dr. Xinzhe Yuan, Missouri S&T

Poster Winners

INSPIRE UTC graduate students from all consortium institutions attended the annual meeting. Participating students interacted with transportation professionals from the government and industry sector. A Graduate Student Poster Session was held, and offered students the opportunity to showcase their research, communicate results to other students, faculty and staff, engage with representatives from the transportation industry, and facilitate interdisciplinary work by exchanging knowledge and ideas between individuals from multiple disciplines.


Dongbin Kim - First Place Winner


Yu Otsuki - Second Place Winner


Pu Jiao - Third Place Winner

PROVOST'S MESSAGE

It's a heady time to be at Missouri S&T. In my first five months as provost, I have met many enthusiastic and inspiring colleagues. On the anniversary of the Kummer gift we are starting to make major financial commitments – including capital projects, student programs, and faculty hires – that will elevate the profile of the university. With the establishment of the Kummer College of Innovation, Entrepreneurship, and Economic Development, consisting of the existing departments of Engineering Management and Systems Engineering, Economics, and Business and Information Technology, we are starting a search for its inaugural dean. In addition to these existing programs, we plan to start initiatives in arts and innovation and the ethics of entrepreneurship. The College of Arts and Sciences (no longer "and Business"!) will have a new dean after three years of service from interim dean, Dr. Kate Drowne. And following Dr. Rich Wlezien's announcement that he was stepping down as dean of the College of Engineering and Computing next year, we are also searching for a dean there. And then there is the re-thinking of the Wilson Library under a new dean, the four Kummer research center directors, numerous endowed department chair positions and professorships.... The list goes on. We are small, but we are becoming mighty, and the next few years promise to be an exhilarating ride.

Dr. Colin Potts
Provost and Executive Vice Chancellor for Academic Affairs

INSPIRE UTC Graduate Student Spotlight

Jinglun Feng is a Ph.D. student in Electrical Engineering advised by Professor Jizhong Xiao at The City College of New York (CCNY) Robotics Lab. His research interests include 3d vision, deep learning, object pose estimation, sensor fusion and intelligent inspection for robotics applications.

Dongbin Kim is a Ph.D. Candidate in Mechanical Engineering at the University of Nevada, Las Vegas (UNLV) and Lab Manager with the Drones and Autonomous Systems Lab (DASL). Research interests include aerial manipulation, haptic-based human-in-the-loop control, embodied human-intelligence, cross reality (XR), and human-embodied interface.

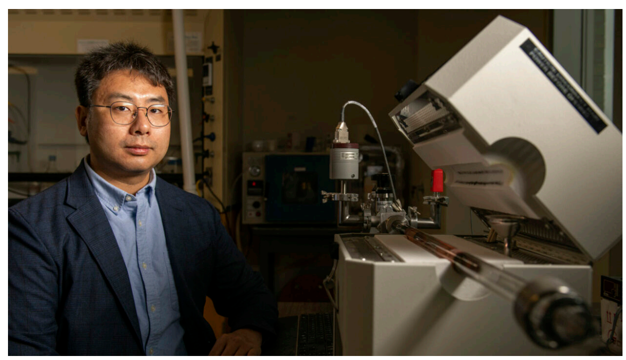
Yu Otsuki is a Ph.D. student in Civil and Environmental Engineering and M.S. in Electrical and Computer Engineering at Georgia Institute of Technology. Yu's research is about autonomous ultrasonic thickness measurement of steel bridge members using a wireless sensing device and a mobile robot.

Ejup Hoxha is a Ph.D. student at The City College, City University of New York (CCNY). Ejup is currently working at the CCNY Robotics Lab as researcher with a focus in robotics, control, visual SLAM, deep learning, sensor fusion, and acoustic NDT.

Deepak Kumar is a Ph.D. student in Structural Engineering at the City College of New York (CCNY). Deepak's research focuses on developing bridge inspection technology. He is developing an automatic electronic sounding device that can be used to detect the defects in the concrete surface effectively.

Dr. Chenglin Wu Wins NSF CAREER Award for 2D Metals Research

As electronic devices get smaller and faster, computer chips must get thinner to save space and improve performance. Dr. Chenglin Wu, an assistant professor of structural engineering at Missouri S&T, has won a $500,000 CAREER Award from the National Science Foundation for his work in two-dimensional metals – metals that are three atoms thick – for use in computer chips, sensors and coatings.



Dr. Chenglin Wu, assistant professor of structural engineering, has won a National Science Foundation (NSF) CAREER Award for his work in 2D metals. Photo by Michael Pierce, Missouri S&T.

"Traditional computer chips are made by stacking silicon dies, but you cannot infinitely thin the silicon or the matrix materials, so there's a need for replacement materials," says Wu. "2D materials are the ideal candidate."

Wu is working with two different types of materials – titanium carbide (Ti_2C) and molybdenum disulfide (MoS_2), each three atoms thick. He says the materials can be stacked like sheets of paper to serve multiple functions, but adhesion and fragility can be challenging. Wu says those challenges limit commercial applications of the technology.

"The 2D materials begin to break down when they undergo a chemical reaction, and they lose their 'stickiness,'" he says. "The real issue is the materials are always under strain, either bent or stretched. With this CAREER Award, I will develop unique tools to study the mechanism that causes the breakdown and find ways to prevent it."

Wu says commercial interest in 2D materials is growing, and the market for the materials is projected to be $6 billion by 2035. He adds that the semiconductor and coating industries are already moving into 2D materials as the cost comes down.

Another industry that could benefit from 2D applications is health care, Wu says. He and other researchers at Missouri S&T are using 2D materials in sensors to detect COVID-19 in people's breath.

"We recently ran a hospital experiment with Phelps Health, and our test was spot-on with the hospital's standard test," he says. "The beauty of it is that our test takes about 30 milliseconds to detect COVID, where the standard test takes 15 minutes. Our test can also differentiate between COVID and the flu."

Wu says S&T researchers are developing a Bluetooth cell phone application that works with a 2D sensor in a mask to detect viruses, sending data from the mask directly to your phone and alerting the testing center. They are also working with collaborators at other universities across the country to develop wearable sensing devices, including a patch that can monitor diabetes using 2D sensor technology.

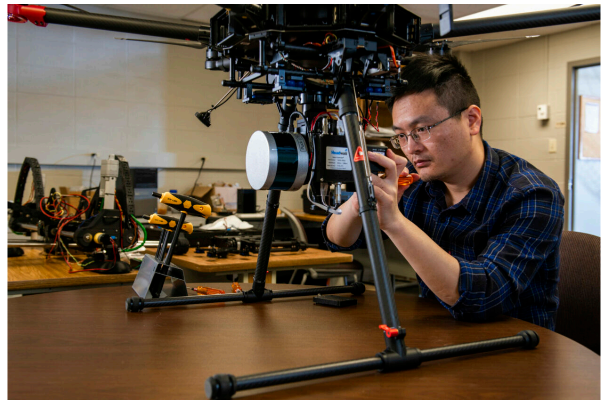
"So that's the future we're working on here," Wu says.

Original Version Posted July 21, 2021-Missouri S&T News and Events

NEWS

Xinzhe Yuan Wins Laegeler Fellowship for Renewable Energy Research

Research involving drones mounted with thermal and hyperspectral cameras to inspect solar panels for damage has won a $70,000 fellowship for Xinzhe Yuan, who will complete his Ph.D. at Missouri S&T later this year. The Laegeler Sustainable Energy Fellowship – from Concept to Reality, created by two Missouri S&T graduates, will provide a stipend and benefits for Yuan to conduct postdoctoral research at S&T.



Xinzhe Yuan, Ph.D. candidate at Missouri S&T, is the winner of the 2021 Laegeler Sustainable Energy Fellowship. Photo by Michael Pierce, Missouri S&T.

“This is a precious opportunity for young Ph.D. students to start a career, and it is good practice in pitching a research idea,” Yuan says. “I appreciate this support for my postdoctoral research.”

The Solar Energy Industries Association predicts that the U.S. solar market will quadruple from current levels by the end of the decade, adding hundreds of thousands of jobs for U.S. workers. Solar panels need regular inspection and maintenance, and that’s where Yuan’s research can help.

“If panels have surface defects, it can affect the output of solar farms,” Yuan says. “The traditional approach is to send people with thermal cameras to inspect the panels, but that is not very efficient. Drones are much faster and can quickly determine which solar panels need repair.”

Yuan, who also holds a graduate certificate in computer science from S&T, adds that, based on data from a California solar farm, it takes humans 195 hours to inspect the farm’s solar panels. Drones equipped with thermal and hyperspectral cameras, which can capture images the human eye cannot see, did the work in four hours. The farm saved $20,000.

Yuan’s research project will be supervised by a multidisciplinary team of Missouri S&T faculty: Dr. Rui Bo, assistant professor of electrical and computer engineering; Dr. Casey Canfield, assistant professor of engineering management and systems engineering; Dr. Sanjay Madria, Curators’ Distinguished Professor of computer science; and Dr. Genda Chen, the Robert W. Abbett Distinguished Professor of Civil Engineering. Each wrote letters of support to the fellowship selection committee.

Chen, who is Yuan’s academic advisor, is also director of S&T’s Center for Intelligent Infrastructure, which will provide much of the research equipment.

The Laegeler Fellowship was established by Missouri S&T alumni Molly and Andy Laegeler. They created the fellowship because they feel strongly that additional research will identify technologies able to bring profitable, sustainable energy to the world.

“We are very excited to provide this postdoctoral opportunity at Missouri S&T,” Molly says. “Our goal in supporting translational research in sustainable energy is to draw awareness to the university for the excellent research it fosters and to provide a vision for bridging the gap between research and practical application in this field.”

“The education we received at Missouri S&T taught us how to solve problems,” Andy says. “We want to encourage great minds to continue working on even bigger problems still outstanding in our world today.”

Original Version Posted June 17, 2021-Missouri S&T News and Events

New Researcher Joins INSPIRE UTC and Center for Intelligent Infrastructure

Zhenhua Shi joined the INSPIRE UTC and CII at the Missouri University of Science and Technology as a research civil engineer in 2021. Before joining CII, which provides administrative support to the operation of INSPIRE UTC, he was a visiting scientist at the Department of Civil, Construction, and Environmental Engineering at the University of Alabama at Birmingham, where he also received his Ph.D. degree in Civil Engineering in 2020. Dr. Shi received his master’s degree from Tongji University in 2015, and his bachelor’s degree from Taiyuan University of Technology in 2011. Dr. Shi is an Engineer Intern with the State of Alabama Board of Licensure for Professional Engineers and Land Surveyors. He also passed the Professional Engineer exam in April of 2019. He was a student intern with the Oak Ridge National Laboratory in Summer 2016-2018. He published seven journal papers and one conference paper as well as two sets of Mendeley Data.

Research Interests:
Structural Health Monitoring (SHM) of Intelligent Infrastructure, Fiber Reinforced Polymer (FRP) Composites, Building Integrated Photovoltaic (BIPV).

Drs. Yi Bao & Genda Chen Recieve MDPI Editor's Choice Award


sensors
an Open Access Journal by MDPI

IMPACT FACTOR 3.576

Indexed in: PubMed

CERTIFICATE
EDITOR'S CHOICE ARTICLES

This certificate is given to

Yi Bao, Matthew S. Hoehler, Christopher M. Smith, Matthew Bundy and Genda Chen

in recognition of the outstanding publication
"Measuring Three-Dimensional Temperature Distributions in Steel–Concrete Composite Slabs Subjected to Fire Using Distributed Fiber Optic Sensors"
Sensors **2020**, *20*(19), 5518, doi:10.3390/s20195518

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Dr. Shu-Kun Lin
President & Publisher
MDPI

Dr. Yi Bao, Ph.D. CE'17, recently had one of his papers selected as an Editor's Choice Article by the journal, Sensor.

The article titled "Measuring Three-Dimensional Temperature Distributions in Steel-Concrete Composite Slabs Subjected to Fire Using Distributed Fiber Optic Sensors" gives detailed information about temperature distribution that can be important to understanding structural behavior in fire. Under Dr. Genda Chen's direction, this study develops a method to image three-dimensional temperature distributions in steel–concrete composite slabs using distributed fiber optic sensors. The feasibility of the method is explored using six 1.2 m × 0.9 m steel–concrete composite slabs instrumented with distributed sensors and thermocouples subjected to fire for over 3 hours. Dense point clouds of temperature in the slabs were measured using the distributed sensors. The results show that the distributed sensors operated at material temperatures up to 960 °C with acceptable accuracy for many structural fire applications. The measured non-uniform temperature distributions indicate a spatially distributed thermal response in steel–concrete composite slabs, which can only be adequately captured using approaches that provide a high density of through-depth data points.

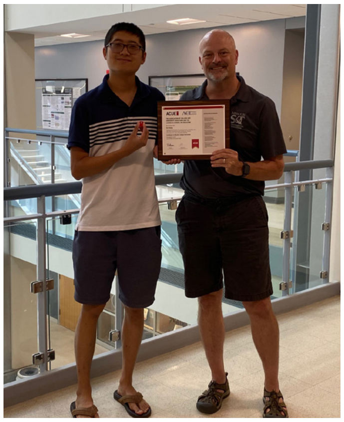
Editor's Choice articles are selected based on their noteworthiness, high interest to readers and are considered among the best in current research.

INSPIRE UTC Associate Director Dr. Hung La Receives an Industry Contract for Software Licensing

In May of 2021, Dr. Hung La completed an industry contract ($149,980) on "Highly Accurate Image Processing for Concrete Images" from Penta-Ocean Constructions Co., LTD., one of the largest construction companies in Japan. This contract was based on a software copyright Dr. La received in July 23, 2019, number TX 8-779-913: "A Universal Convolution Neural Network (U-CNN) for Highly Accurate Defect Detection in Civil Infrastructure Inspection."

NEWS

Dr. Bo Shang Receives Certificate for the ACUE Teaching Workshop



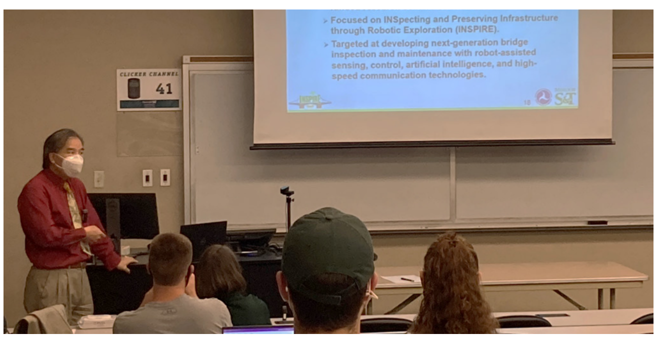
Dr. Bo Shang with the Civil Engineering Department Chair, Dr. Joel Burken

Dr. Bo Shang believes teaching can help his learning and help him understand materials at a deeper level. Bo has previous experience of teaching as a lecturer at University of California. At that time, he taught mechatronics, engineering computing, and unmanned aerial systems and discovered that teaching could be part of his career. Upon joining the Missouri University of Science and Technology (Missouri S&T), he actively seeks for opportunities to improve his teaching skill.

In June 2020, Shang learned that he could have a chance to be one of 60 faculty at S&T to join the "Scaling Instructional Excellence for Student Success" program. The program is a collaboration among the Association of College and University Educators (ACUE), the University of Missouri System, and the Missouri S&T Center for Advancing Faculty Excellence (CAFE). Although he has intensive responsibility in doing research, Dr. Shang completed the 25 modules with an average of 3-5 hours of activity per week for 6 months. Upon completion, he received $1,000 stipend and was awarded ACUE's Certificate in Effective College Instruction which is recognized and endorsed by the American Council on Education (ACE). After this program, he understood that teaching is not an easy task and is not only about the transferring of knowledge, but also creating an inclusive and supportive environment, promoting active learning, and designing student centered courses. In essence, teaching is an endless iterative process for practice and reflection.

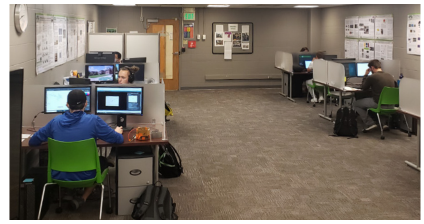
Dr. Shang will use what he learned to help with training the next generation of workforce in education. He plans to help create student centered courses and integrate those ideas in developing teaching equipment with cutting-edge technologies including virtual reality (VR) and augmented reality (AR). These courses and equipment will help future bridge experts make full use of robotics technology.

Dr. Chen Presents Cross-disciplinary Training to Students of the American Civil Engineering Honor Society



On September 7, 2021, INSPIRE UTC Director, Dr. Genda Chen, made a presentation on "Extended Opportunities through Cross-disciplinary Training: Robot-assisted Bridge Preservation" to student members of the 35th Chapter of American Civil Engineering Honor Society, which was found on May 20, 1922. The Missouri S&T Chapter was established in 1950. Dr. Chen envisioned the new trends of emerging technologies such as artificial intelligence, augmented reality, digital twin, high speed internet, remote sensing, and robotics and their potential adoptions in civil engineering practices particularly in construction and transportation industries. He introduced and analyzed new employment opportunities through cross-disciplinary training on specific technologies such as big data analytics, augmented and virtual reality, and 3D printing and modeling. About 20 Chi Epsilon students enthusiastically participated in this meeting and active discussion. Dr. Chen shared his insights on the impact of the Industry 4.0 technologies on civil engineering job opportunities. He illustrated the shortage of workforce in construction and transportation sectors that master the modern technologies. Students who are well trained in interdisciplinary engineering will position themselves for more and better-paid employment opportunities.

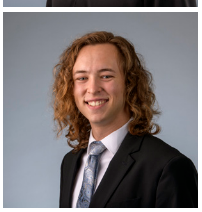
Undergraduate Research Students Bring New Experiences to CII & INSPIRE UTC



Undergraduate student assistants play an integral role in various research and education activities at the INSPIRE UTC. At their creative ages, they can provide unique insights and skills for specialized tasks in different engineering disciplines such as civil, electrical, and mechanical engineering as well as computer science and engineering. At the same time, they are receptive and flexible to learn and absorb new knowledge, thus benefiting from their involvement and services at the INSPIRE UTC.

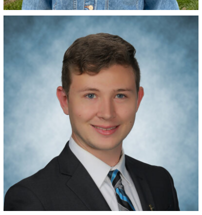
Maria Alvarado is a senior in civil and architectural engineering. Maria's main role in Dr. Genda Chen's INSPIRE UTC research is to investigate the use of augmented reality and possible applications of such technology when used for bridge inspections, with special interest in bridge data collection and assembly into a coherent GIS database. Maria is also a member of the Society of Hispanic Professional Engineers (SHPE)

Derek Edwards is a senior in mechanical engineering. He has served as an administrative assistant at INSPIRE UTC for more than a year but recently has moved to serve a dual position and taken on additional responsibilities as an undergraduate research assistant. Derek is assisting in the development of the BIRDS clamping system to attach a drone to the bottom flange of a girder for more effective and efficient inspection of the girder and bridge deck. He is also involved on campus with the Formula SAE Design Team as the suspension project engineer for the 2022 season.



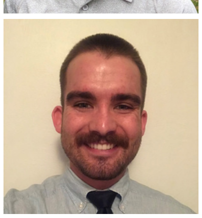
Daniel McDonald is a junior in electrical and computer engineering. He is an INSPIRE UTC Undergraduate Research Assistant working to develop Internet of Things (IoT) devices to help monitor and maintain civil infrastructure. His role involves reviewing and designing IoT devices and technologies that enable the collection and transmission of data while conforming to power constraints. Daniel is a member of Missouri S&T's Institute of Electrical and Electronics Engineers chapter and the Electrical Team Lead on the Miner Motorcycle Design Team.

Ava Ramljak is a junior in computer engineering. Her role in Dr. Genda Chen's INSPIRE UTC research project is to help setup ROS for TreeFrog climbing robot as a step towards preparing the setup for more complex maneuvers. Another key role Ava plays in the INSPIRE UTC team is helping Dr. Bo Shang with BIRDS by seting the Vicon Motion Capture system for accurate external position measurement. Ava is an active member of Spectrum and is planning on pursuing her Master's in computer engineering at S&T.



Andrew Rawlings is a senior in mechanical engineering. His role in Dr. Genda Chen's INSPIRE UTC research project is to assist in the design and application of an unmanned traversing system called TreeFrog to be used to inspect bridges. This system will walk down the side of concrete that are partially submerged in water using vacuum suction. Ultimately, the system will use a sonar sensor to gather data on the submerged portion of the pillar to be analyzed for defects. Andrew is the President of Pi Kappa Alpha, a social and philanthropic organization.

Joseph Ressel is a senior in mechanical engineering. Joseph has assisted the development of many projects including the newest version of the BIRDS project for use in scanning bridges decks for defects as well as the TreeFrog inspection robot. He has also designed a device to test and calibrate the sensors used on drones. Analyzing the use of thermal cameras to check for voids in concrete has also been one of his projects. Finally, Joseph has been working to optimize a new design of an environmentally friendly intercity and intracity transportation system.



Matthew Weiss is a senior in mechanical engineering, with a minor in business management. Matt joined INSPIRE UTC as a head student administrative ambassador for INSPIRE UTC and CII. Currently, while retaining his previous role, he also works as a research assistant on the BIRDS project. Last summer, Matthew completed an internship at BNSF Railway as an engineering intern for the track department. Matthew is also a member of the Phi Kappa Theta fraternity, a social and philanthropic organization.

EDDY CURRENT SENSOR INTEGRATED ROBOTIC SOLUTION FOR STEEL STRUCTURE INSPECTION

Inspection of mechanical and structural components in steel bridges, ships, aircrafts, pipelines, and tanks should be thoroughly carried out on a regular basis to avoid unexpected accidents that may occur due to steel fatigue and fracture, which leads to potential fatality and economic loss [1]. The demand for quality inspection on steel welds is high in many engineering fields. However, the use of human workers for visual inspection will face many difficulties as inspectors have to work intensively in dangerous environments with limited mobility. Inspectors with different training sometimes provide inconsistent, if not incorrect, inspection results since it is difficult for humans to perform tasks perfectly. As a nondestructive testing (NDT) technique, Eddy current or electromagnetic induction test [2] can be used to detect defects (i.e., fatigue cracks at welded connections and in steel members) of the steel structures. To alleviate the burden on inspectors and increase the productivity and quality of their inspection, we have designed and built a robot that can carry the NORTEC® 600 equipment (an Eddy current sensor) to collect eddy current data automatically. In this newsletter, we will present the NORTEC® 600 sensor and its integration with our developed climbing robot. Different versions of our climbing robot design can be referred to [3-7].

The NORTEC® 600 (Fig. 1) manufactured by Olympus (https://www.olympus-ims.com/en/nortec600/) combines the latest innovations in eddy current testers with a compact and rugged design. The NORTEC® 600 flaw detector offers outstanding performance for steel surface inspection and aerospace applications (Fig. 1). The NORTEC® 600 can quickly and easily conduct surface inspections, wheel inspections, and bolt-hole inspections.

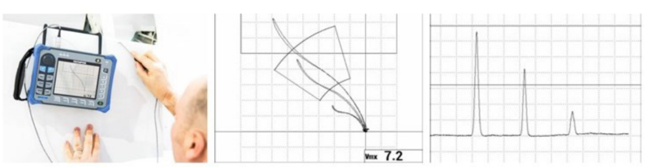


Figure 1. Surface inspection using NORTEC® 600.

The provision of alarm output ports when detecting defects allows the connection of peripheral devices to automate the data collection process.

Overall, the robot in Fig. 2 consists of an aluminum frame and a scanning frame made of hardened steel rods. The frame has a belt system that is used to maneuver an Eddy Current probe around a scanning area. There are four large ring magnets, which make up the inside of the robot's wheels. Each magnet generates an attractive force of 1126.7 N. On top of the frame above the wheels lies the computer that controls the wheels, camera, and set of stepper motors. On the very top is where the NORTEC® 600 rests securely. When scanning, the eddy current probe is moved in a line-by-line pattern throughout the scanning area. The robot is powered with 2 LiPo batteries 4s 6000 mAh and has a run time of 60 minutes before recharging. Due to strong magnetic forces, deployment of the robot must be cautious. In our practice, the robot on a non-metal work surface is carefully placed onto the steel member until the four magnets pull the robot off the work surface. Alternatively, a ramp can be used to roll the robot down and onto the steel member directly. The robot can be removed from the steel by making use of this ramp.

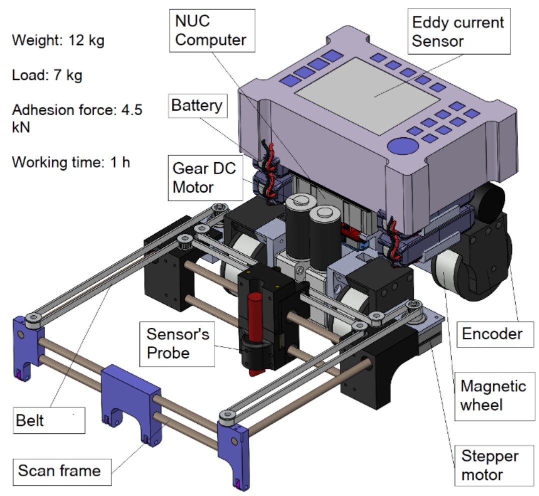


Figure 2. CAD model and specification of the robot.

The manufactured robot has an aluminum frame with an area of 20.5 cm × 18.7 cm with a thickness of 1.2 cm or more. The scanning area measures 17.6 cm × 16.76 cm, and the total size of the robot occupies 45.65 cm × 31.2 cm × 21.73 cm. Two trip switches have been created through the addition of two aluminum strips to help the robot determine the starting position (home position) of the Eddy Current probe for travel in x or y direction.

The robot control system (Fig. 3) consists of a high-level controller, which is the NUC computer, camera, IMU, NORTEC® 600, and two low-level controllers "MOVING CONTROL", "SCANNING CONTROL", encoders, and limit switches.

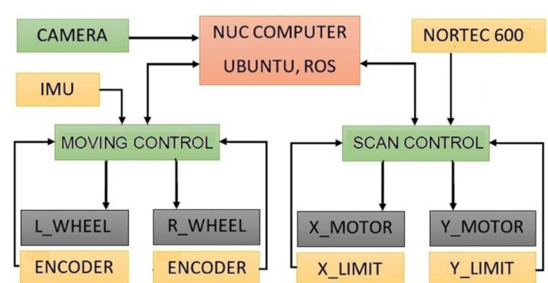


Figure 3. Control system of the robot.

In teleoperation mode, the Robotic Operating System (ROS) in the NUC computer (Fig. 3) commands the moving and scan nodes (low-level control) for Eddy current data collection, captures and sends a live camera image to a ground station, runs a path planning algorithm [3] based on the odometry feedback ROS node, when in auto navigation mode, and saves collected data. The moving control ROS node (Arduino Mega) receives a command from the computer to control speed motors, reading encoders and IMU feedback, and then sends back to the Odom ROS node. The scan ROS node (Arduino Uno) receives the command start, and calculates the scanning path and exports signal to control stepper motors, while reading data from NORTEC® 600 and sends them to the data saving node.

To demonstrate the robot's ability to move on steel surfaces, we conducted various tests such as Fig. 4-5. The robot was successfully demonstrated to move stably and safely while carrying the NORTEC® 600 sensor.

Figure 4. Robot testing on a curved steel surface.

Figure 5. Testing the robot on a flat steel structure and pass the angle 90°.

During the tests, the robot gathered some data from the steel surface with the eddy current sensor (NORTEC® 600). When the eddy current data was retrieved, we could create a defect map of the steel surface on which the robot had scanned. This allows the collected data to be reviewed in a quick and intuitive manner. The created robot would allow a technician to complete a detailed and thorough inspection of a steel bridge or structure without a need for a deep knowledge of steel.

Fig. 6 presents data collected during an indoor experiment on a 7 cm × 17 cm steel surface with artificial cracks. The data includes the eddy current sensor signal (z, dB) and the probe position (x, y, cm). The x,y, and z are saved in .csv extension in the onboard NUC computer with a sample time of 0.1 s. The heat map is created to represent the data in MATLAB. For the ease of illustration, a color coded map was generated as shown in Fig. 6. It can be seen from Fig. 6 that the eddy current reading/fatigue crack map are corresponded well to each other in the crack areas shown in red/yellow colors.

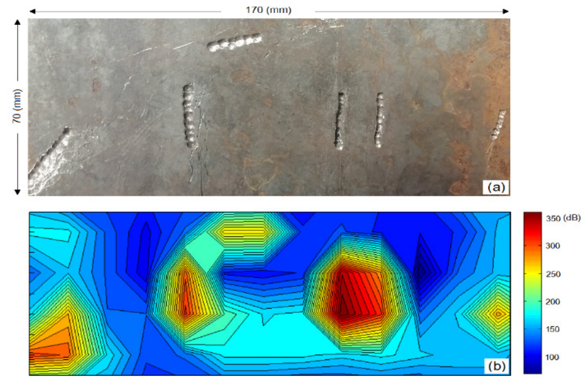


Figure 6. a) Image of an inspected area with cracks on it; b) Fatigue crack map from Eddy current sensor showing defect areas with red/yellow color, corresponding well with the crack areas on the image.

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ABOUT THIS PROJECT

Led by Dr. Hung La, Associate Professor at the University of Nevada, Reno, the *Climbing Robots with Automated Deployment of Sensors and NDE Devices for Steel Bridge Inspection* project is part of the INSPIRE UTC Research Program led by Missouri University of Science and Technology.

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AUTONOMOUS ULTRASONIC THICKNESS MEASUREMENT ON STEEL BRIDGE MEMBERS BY A MAGNET-WHEELED MOBILE ROBOT

Current steel bridge inspections are primarily a visual activity, requiring an inspector to reach within arm's length to a structural member surface for thorough examination. The inspection process can be labor-intensive and often entails expensive snooper trucks or lane closures. While human inspection is necessary, the latest robotics technologies can be adopted to ease inspector efforts and provide additional data for bridge condition assessment.

Through previous research, the Martlet wireless sensing device was developed by Dr. Wang's group at Georgia Institute of Technology (GT) and collaborators. The Martlet motherboard (2.5 in x 2.35 in) operates at 3.3V and runs on a small battery pack. The motherboard contains a microprocessor and a 2.4 GHz Zigbee-compatible radio that demonstrated communication over 800 meters at line of sight. Modular design of the wireless sensing devices allows various daughter boards to be stacked on top of the motherboard, in different sensing applications.

In particular, our recent development of two daughter boards provides a compact solution for wireless ultrasonic thickness measurement of steel bridge members. Fig. 1 demonstrates the functional diagram of our latest development that enables the Martlet wireless sensing device with high-voltage ultrasonic excitation and high-speed data collection.

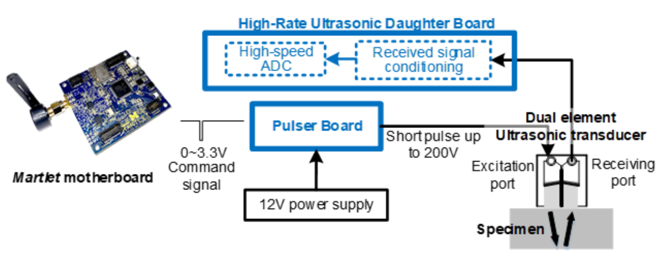


Figure 1. Functional diagram for thickness measurement.

Commanded by the motherboard, the pulser daughter board can generate a high-voltage short-duration pulse excitation to a dual-element ultrasonic transducer, which in turn launches ultrasonic wave on the surface of a steel specimen. After reaching the other side of the specimen, the wave is reflected and generates response in the same transducer.

The response signal is fed into the high-rate ultrasonic daughter board which is capable of filtering/amplifying the ultrasonic signal and perform high-speed analog-to-digital conversions (up to 80 MHz). The sampled data is transferred to the Martlet motherboard through the serial-peripheral-interface protocol. In the end, the Martlet motherboard can wirelessly send the data to a base station.

The response signal collected by the motherboard can provide the Time of Flight (ToF) of the ultrasonic wave. The ToF is usually around tens of microseconds and used to estimate the thickness of the steel member. The technique can conveniently detect any thickness loss caused by corrosion. The accuracy of the thickness measurement by the developed Martlet ultrasonic device has been verified in laboratory and field testing.

The exploded view in Fig. 2 summarizes the latest Martlet ultrasonic device, including the Martlet motherboard, the high-rate ultrasonic daughter board (top and bottom views), and the pulser daughter board on top. Key components on the daughter boards are marked in the Fig. 2

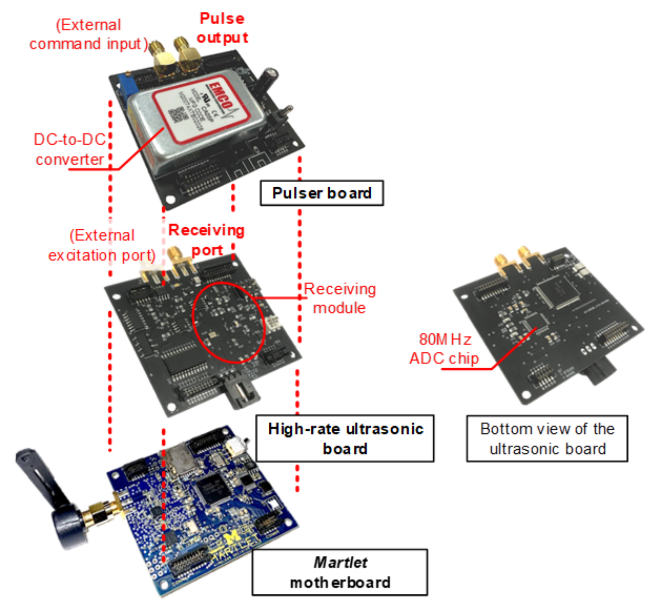


Figure 2. Martlet wireless sensing device for ultrasonic thickness measurement.

In parallel to the wireless ultrasonic thickness measurement, latest robot platforms developed by Dr. La's group at the University of Nevada, Reno (UNR) demonstrate promising performance navigating on steel bridge members. Marrying the two state-of-the-art developments, this project has produced a magnet-wheeled mobile robot capable of autonomous ultrasonic thickness measurement of steel bridge members.

In May 2021, GT graduate student Yu Otsuki visited Prof. La's lab and worked with UNR graduate student Son Nguyen to integrate the Martlet ultrasonic device with a UNR bicycle mobile robot (Fig. 3). A pumping mechanism was developed to apply an appropriate amount of gel couplant between the transducer and the steel surface, which strengthens the propagation of the ultrasonic wave into the specimen.

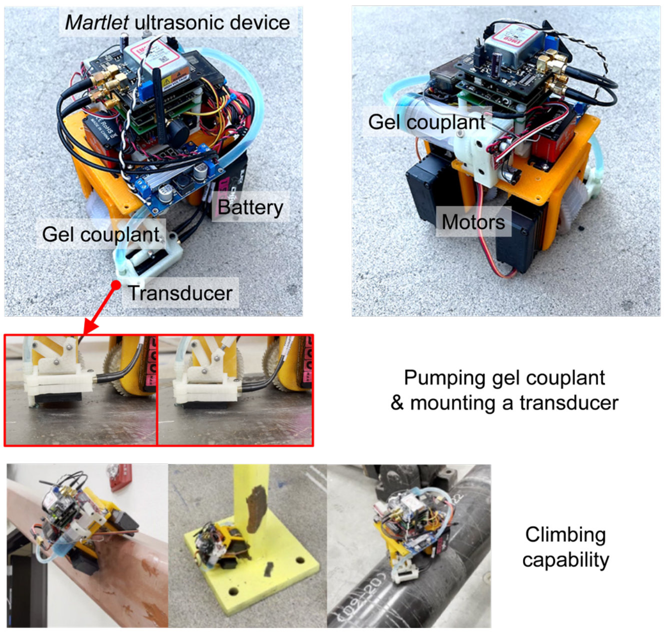
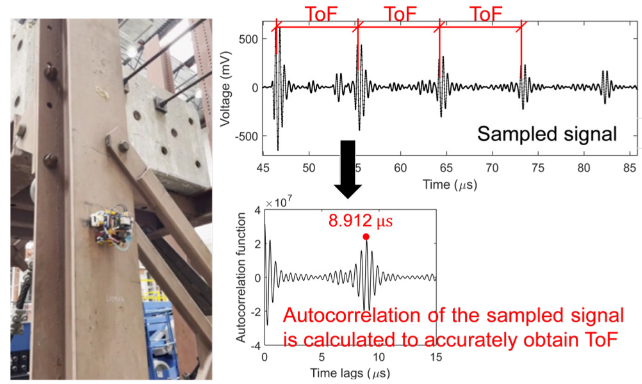


Figure 3. Steel climbing robot incorporating the Martlet ultrasonic device.

A mounting/retrieving mechanism of the transducer was designed to ensure a reliable contact between the transducer and the steel surface. Climbing capability of the mobile robot was verified on different types of steel surfaces as shown in Fig. 3.

To validate the thickness measurement accuracy performed by the robotic system, laboratory testing was conducted on a 1-inch-thick steel plate at the UNR Earthquake Engineering laboratory. The developed system obtained high-quality ultrasonic waveforms as shown in Fig. 4, the developed system obtained high-quality ultrasonic waveforms, from which an autocorrelation function is obtained and provides the ToF as 8.912 μs. Using the standard wave velocity of 0.2339 in/μs, the steel thickness is finally estimated to be 1.04 inch, which is nearly equal to the nominal 1 inch thickness.



$$\text{Thickness} = \frac{\text{ToF} \times \text{Velocity}}{2} = \frac{8.912\ \mu s \times 0.2339\ \text{in}/\mu s}{2} = 1.04\ \text{in}$$

Figure 4. Steel thickness measurement by the climbing robot carrying Martlet ultrasonic device.

In summary, a compact ultrasonic thickness measurement device has been developed based on the Martlet wireless sensing system. The device is capable of high-voltage excitation, filtering/amplification of the received ultrasonic signal, high-speed analog-to-digital conversions (up to 80 MHz), as well as wireless data transmission. After integration with a steel climbing robot developed by UNR, the mobile sensing system successfully obtained accurate thickness measurement in laboratory testing. To further validate the performance of the developed system, field testing on steel bridges will be conducted. The measurement accuracy on severely rusted steel surfaces will also be investigated.

ABOUT THIS PROJECT

This collaborative project is led by Dr. Yang Wang in Civil and Environmental Engineering at the Georgia Institute of Technology, and Dr. Hung La in Computer Science and Engineering at the University of Nevada, Reno. This project is part of the INSPIRE UTC Research Program led by Missouri University of Science and Technology.

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ROBOT-BASED GPR DATA COLLECTION AND 3D RECONSTRUCTION

As one of the most popular radio wave sensors, ground penetrating radar (GPR) is widely used in the field of non-destructive testing (NDT) to detect, interprete and reconstruct underground targets. GPR uses a wave propagation technique to send pulses of polarized high-frequency radar waves into the subsurface media and the GPR antenna records the strength and traveled time of each reflected pulse (i.e., A-scan) when it encounters a material change. As a human operator pushes a GPR cart to survey underground objects, the GPR antenna produces a series of A-scans at different locations. The ensemble of A-scans forms a B-scan from which hyperbolic features are used to indicate the presence and location of a target. Many GPR imaging methods are proposed to reveal and model subsurface targets, including back-projection (BP) algorithm [1] and deep neural network (DNN) [2].

The current manual practice is time consuming and tedious. A two-man crew takes two hours to mark grid intersection nodes on a 200 ft × 200 ft site. Considering a grid spacing of 0.5 ft, the total grid line distance to cover the entire site is 160,000 ft (30.3 miles). The operator must push the GPR cart to precisely follow the straight lines in both X and Y directions and rely on a survey wheel encoder to trigger the GPR sampling.

This article presents a robotic solution to automate the GPR data collection and 3D reconstruction. As illustraed in Fig. 1, a triangle-shaped omni-directional robot carries a GPR antenna at the bottom of its chassis to conduct data collection, an RGB-D depth camera with a 6-axis IMU to provide accurate positioning, and an Intel NUC computer to synchronize the positioning data with GPR measurements. Three specially designed omni-wheels enable the robot to move forward, backword and sideways without rotation, and thus faciliate GPR data collection in all directions. The robot motion is governed by the following equation:

$$\begin{bmatrix} v_{w1\_drv} \\ v_{w2\_drv} \\ v_{w3\_drv} \end{bmatrix} = \begin{bmatrix} 1 & 0 & -d \\ \cos\frac{2\pi}{3} & \sin\frac{2\pi}{3} & -d \\ \cos\frac{-2\pi}{3} & \sin\frac{-2\pi}{3} & -d \end{bmatrix} \begin{bmatrix} v_x \\ v_y \\ \omega \end{bmatrix}$$

where v_{w1_drv}, v_{w2_drv}, *and* v_{w3_drv} represent the linear velocities of three omni-wheels, respectively; d indicates the distance between the center of a wheel and the center of the robot body; v_x, v_y, and ω denote the linear velocities and angular velocity of the robot body, respectively.

Instead of a wheel encoder for linear motion recording, an RGB-D tracking camera is used to accurately estimate the robot pose (position and orientation) in real time, and record the continuous free motion automatically.

We implement a time synchronizer software under ROS (Robot Operation System) and tag pose information at each GPR sample. It enables the robot to scan the ground surface in free motion pattern and facilitates high-resolution 3D GPR imaging. With the pose data and GPR B-scan raw data as inputs, we develop an efficient DNN-based 3D GPR imaging method to produce sharp images and a dense model of the subsurface target directly from the GPR data.

Figure 1. The robotic data collection module

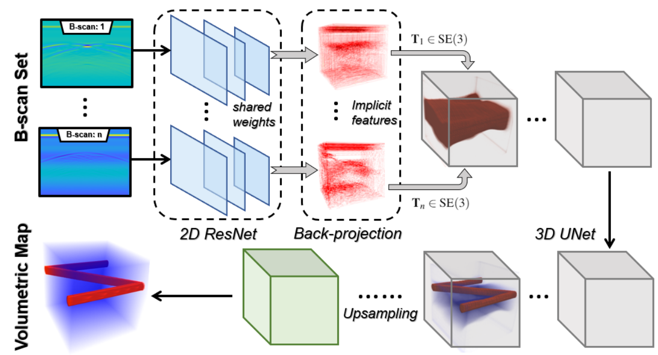

Figure 2. DNN-based 3D GPR imaging method to produce the 3D volumetric model of subsurface objects.

Given a set of measurements,

$$S = \{B_i, T_i \mid i = 0, \dots, n\}$$

where $B_i \in R^{1\times h\times w}$ represents a B-scan that is associated with its pose $T_i \in SE(3)$. We want to learn a model f_v that reconstructs the 3D subsurface volumetric map with ground truth volume V_t supervision. The predicted target volume is defined as:

$$\hat{V}_t = f_v(S)$$

Using the DNN-based learning method [3], the model f_v is composed of a 2D ResNet as B-Scan encoder, a 3D U-Net as structure encoder, and an occupancy prediction process. The 2D ResNet encoder (i.e. ResNet34) takes in the input B-scan to predict a 3D feature volume, which emulates the conventional BP process. Once we obtained the feature volume of all B-scans, we transform each B-scan feature volume and aggregate it into a global feature volume. The 3D U-Net encoder takes the aggregated feature volume as input and further learns to extract salient features to allow subsurface object prediction. The 3D U-Net encoder is followed by a two-layered process to estimate the occupancy volume, which is our prediction to compare with the ground truth.

To evaluate the effectiveness of our proposed method, we conducted field tests on the CCNY/InnovBot concrete slab as shown in Fig. 3. The reconstruction results demonstrate that the conventional BP method introduces too much noise while our method could produce a much better volumetric model of the target objects.

In addition, we use gprMax software to generate 627 synthetic models of cylinderic, cubic and spherical objects with different

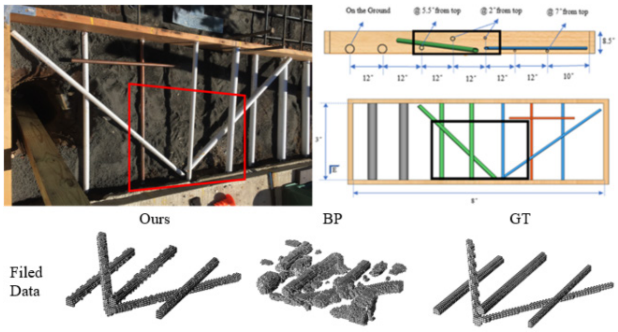

Figure 3. Field test on concrete slab buried with pipes. The bounding box indicates the data collection area. Bottom: GPR reconstruction results using our method, BP method and ground truth (GT).

sizes, shapes and depths embedded in the concrete slab. Fig. 4 shows that our method can recover a volumetric model of the objects while the conventional BP method introduces too much noise and cannot recover the size and clear geometry of the objects. We also conducted a comprehensive study to quantitatively compare the 3D reconstruction results using different benchmarks, including intersection-over-union (IoU), the area under the receiver operating characteristic curve (AUC), accuracy (A.), precision (P.), recall (R.), and F1 score. These comparisons between our method and the BP method are illustrated in Tables 1 and 2.

Table 1. Identification success (%) of cylindric objects.

Model	IoU	AUC	A.	P.	R.	F1	SP.
Ours	93.2	98.3	99.5	89.3	96.9	92.9	99.6
GPRNet	63.9	66.0	98.3	74.7	32.3	44.8	99.8
BP	37.5	38.2	68.7	18.9	32.3	23.9	58.0

Table 2. Identificaiton success (%) of noncylindric objects.

Model	IoU	AUC	A.	P.	R.	F1	SP.
Ours	64.4	74.9	93.9	46.3	53.5	49.6	96.3
BP	20.5	19.8	60.1	12.8	30.9	18.0	53.8

In summary, the proposed robotic GPR data collection system eliminates the time, hassle, and cost to laying out and closely following grid lines on flat terrain. The quantitative and qualitative comparison of field test and simulation study on synthetic dataset verified that our proposed DNN-based 3D GPR imaging method outperforms the conventional BP approach in reconstructing the 3D volumetric model of underground targets.

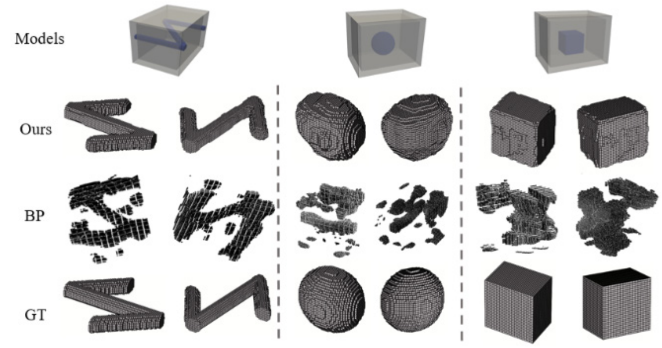

Figure 4. Reconstruction results on the synthetic dataset using our method, BP algorithm, and ground truth (GT) data.

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ABOUT THIS PROJECT

This article was prepared by Mr. Jinglun Feng, PhD candidate in Electrical Engineering at the City College of New York, under the supervision of Prof. Jizhong Xiao. The project is partially supported by INSPIRE UTC under Grant No. 69A3551747126, and NSF SBIR program under grant No. 1915721 and No. 2112199. For his Ph.D. study, Feng aims to automate GPR data collection using visual geometry and robotic techniques, interpret GPR data and reconstruct the 3D model of subsurface objects. Prof. Jizhong Xiao has significant financial interest in InnovBot LLC, a company involved in R&D and commercialization of the technology.

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INSPIRE UTC AND CII LAUNCHES A VIDEO SERIES ON FRONTIERS IN INFRASTRUCTURE RESEARCH AND EDUCATION (FIRE)

The Center for Intelligent Infrastructure (CII) at Missouri University of Science and Technology (Missouri S&T) proudly presents a new video series called Frontiers in Infrastructure Research and Education (FIRE). This FIRE video series will be uploaded to the CII YouTube website and made available to the public. CII is a university research center that provides administrative support to externally funded programs, such as the USDOT-sponsored Tier 1 INSPIRE University Transportation Center led by Missouri S&T and Missouri S&T site of the USDOT-sponsored Region VII Mid-America Transportation Center led by the University of Nebraska, Lincoln.

With the advent of Industry 4.0 technologies, such as artificial intelligence (AI), augmented reality, digital twin, high-speed internet, and robotics, opportunities arise in front of us to rejuvenate century-long civil engineering. CII takes these unprecedented opportunities to improve inspection safety, efficiency, and reliability towards effective preservation of our nation's aging infrastructure, such as bridges, dams, levees, ports, rail, roads, and transit. As an example, 42% of over 610,000 bridges in the United States are exceeding their design life of 50 years, and 7.5% of the bridges that support 178 million trips every day are considered in "poor" condition.

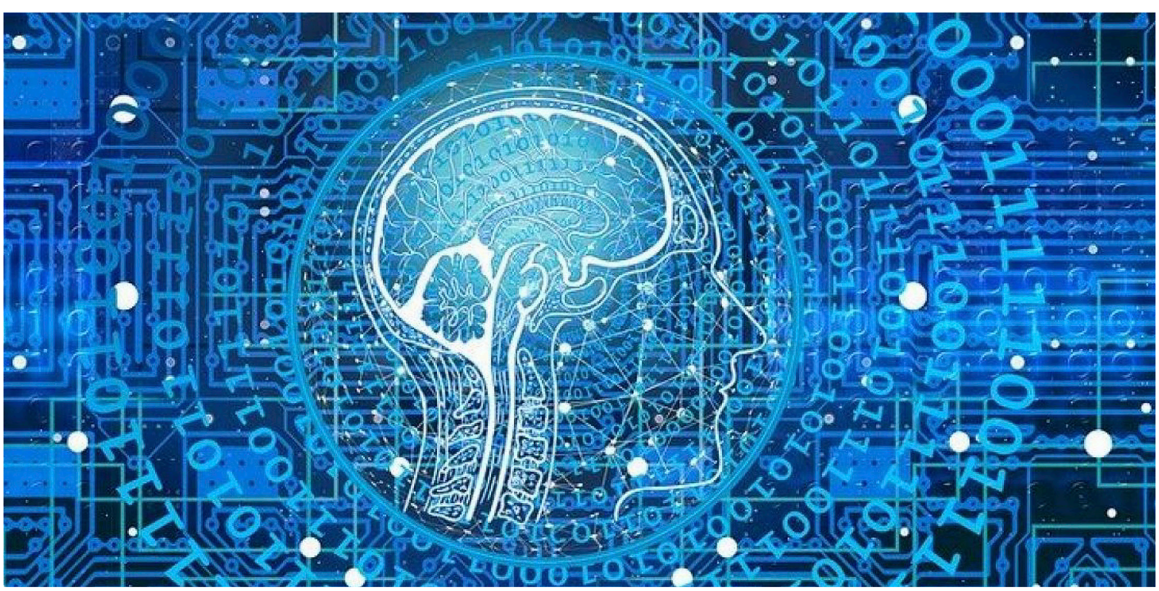
In this episode, we introduce AI into the asset management of bridge infrastructure and demonstrate the power of AI in assessing the condition of bridge elements. Due to security and liability, the application of AI in civil infrastructure likely encounters three technical challenges: big data acquiring, explainable data mining, and inspectors-in-the-loop training.

To develop a big database, the INSPIRE UTC has launched a pooled-fund study coordinated by Missouri Department of Transportation to inspect 72 steel-girder and prestressed concrete girder bridges in seven states and conduct optical, thermal, and hyperspectral imaging as well as LiDAR scanning. Our goal is to reveal both surface and subsurface condition states of key bridge elements and visualize them in a 3D reconstruction model of a bridge system.

To explain the process of data mining, the INSPIRE UTC has begun to explore a normalization and orthogonalization approach to establish the causal relation between input and output data on their principal components based on physical or electrochemical processes. This external approach expects to provide partial insights on a traditionally black box of AI in engineering applications.

To make effective use of AI outputs in decision-making, bridge inspectors would like to provide expertise in AI training and output reasoning for the condition assessment of bridge elements. To this endeavor, the INSPIRE UTC has developed a deep learning framework to promote human-AI collaboration in bridge element segmentation on a video format. Once tailored to a small initial training dataset labeled by inspectors, a transferred learning model teaches itself to label new data. Those that are mislabeled by the model are thus annotated correctly by inspectors. With a few rounds of computer labeling and inspector confirmation, the semi-supervised model can iteratively achieve satisfactory performance.

Most bridge projects are for bridge rehabilitation and deck replacement. Currently, the INSPIRE UTC is focused on the asset management of existing bridges. However, as it continues to advance, AI has the potential to penetrate through every step in the creation process of engineered infrastructure from design through construction to operation. When it does, we will enter an era of artificial infrastructure intelligence (AI^2).



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Hosted by University of Central Florida, in Orlando, Florida

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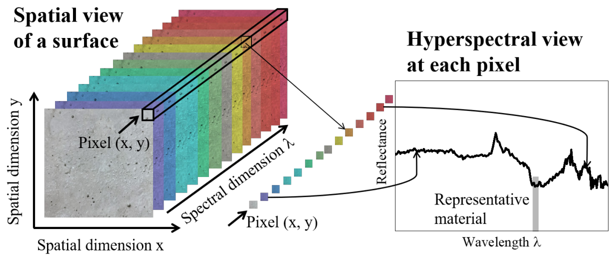
Notification of Acceptance: January 15, 2022
Full paper Submission Deadline: March 31, 2022
CONFERENCE: June 5-8, 2022

INSPIRE WEBINARS

UPCOMING WEBINARS

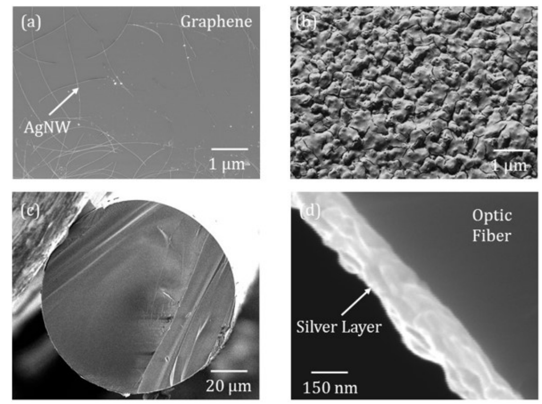


HYPERSPECTRAL IMAGING AND DATA ANALYTICS FOR CIVIL INFRASTRUCTURE INSPECTION

Present: December 14, 2021, 10:00AM-11:00AM (CST)
Speaker: **Dr. Genda Chen**
Professor and Robert W. Abbett Distinguished Chair in Civil Engineering, Director of INSPIRE UTC, and Director of CII
Register: **inspire-utc.mst.edu/webinars**

In this 50-minute lecture, the fundamental concept of hyperspectral imaging is reviewed. Each hyperspectral image represents a narrow, contiguous wavelength range of an electromagnetic spectrum, which could be indicative of a chemical substance. All the images in the spectral range of a hyperspectral camera are combined to form a three-dimensional hyperspectral data cube with two spatial dimensions and one spectral dimension. A hyperspectral cube can be sampled in four ways: spatial scanning, spectral scanning, snapshot imaging, and spatio-spectral scanning. This presentation will be focused on spatial scanning from a line-scan camera. The feasibility of horizontal imaging from a synchronized hyperspectral camera and LiDAR scanner system will be explored first. The hyperspectral images are then applied into several infrastructural inspections: concrete roadway condition assessment, fresh mortar strength evaluation, chloride concentration determination in reinforced concrete, steel reinforcing bar and steel plate corrosion, and surface plant stress monitoring as an indication of gas leakage from embedded pipelines. As an example, mortar samples with a water-to-cement (w/c) ratio of 0.4-0.7 were cast and scanned during curing. Reflectance data at a wavelength range of 1920 nm to 1980 nm, associated with the O-H chemical bond, were averaged to classify different mortar types with a Support Vector Machine (SVM) algorithm and predict their compressive strength from a regression equation. After baseline and bias corrections, the reflectance intensity at 2258 nm wavelength was extracted to characterize Friedel's salt. The possibility of steel corrosion was experimentally shown to increase with the characteristic reflectance intensity that in turn decreases linearly with the diffusion depth at a given corrosion state. For each type of mortar cubes with a constant w/c ratio, the characteristic reflectance intensity linearly increases with chloride ion Cl- concentration up to 0.8 wt.%.

RECENT WEBINARS



FIBER OPTIC SENSOR BASED CORROSION ASSESSMENT IN REINFORCED CONCRETE BRIDGE ELEMENTS AND METAL PIPELINES

Presented: June 16, 2021
Speaker: **Dr. Genda Chen**
Professor and Robert W. Abbett Distinguished Chair in Civil Engineering, Director of INSPIRE UTC, and Director of CII
Missouri University of Science and Technology

IMAGE-BASED BRIDGE DEFECT DETECTION AND MONITORING TECHNOLOGIES

Presented: September 14, 2021
Speaker: **Dr. Jian Zhang**
Professor of Civil Engineering
Southeast University, China

RECENT KEYNOTE/INVITED PRESENTATIONS

- Genda Chen. "***Robot-assisted Bridge Inspection and Maintenance – a Futuristic Perspective***," Annual Infrastructure Advancement Institute Meeting, Houston, Texas, September 27-29, 2021.
- Genda Chen. "***Extended Opportunities through Cross-disciplinary Training: Robot-assisted Bridge Preservation***," Chi Epsilon meeting at Missouri University of Science and Technology, Rolla, MO, September 7, 2021.
- Genda Chen. "***Robot-assisted Bridge Inspection and Maintenance***," Southeast University, Nanjing, China, July 26, 2021.

WEBINAR ARCHIVES

2021

Image-Based Bridge Defect Detection and Monitoring Technologies
By Dr. Jian Zhang, Southeast University, China, September 14, 2021

Fiber Optic Sensor Based Corrosion Assessment in Reinforced Concrete Bridge Elements and Metal Pipelines
By Dr. Genda Chen, Missouri S&T, June 16, 2021

Human-Robot Collaboration for Effective Bridge Inspection in the Artificial Intelligence Era
By Dr. Ruwen Qin, Stony Broook University, March 23, 2021

2020

Artificial Intelligence-Empowered Civil Engineer
By Dr. Hui Li, Harbin Institute of Technology; Harbin, China, December 8, 2020

UAV-Enabled Measurement for Spatial Magnetic Field of Smart Rocks in Bridge Scour Monitoring
By Dr. Genda Chen, Missouri S&T, September 14, 2020

Mobile Manipulating Drones
By Dr. Paul Oh, University of Nevada, Las Vegas, June 17, 2020

Non-Contact Air-Coupled Sensing for Rapid Evaluation of Bridge Decks
By Dr. Jinying Zhu, University of Nebraska, Lincoln, March 12, 2020

2019

Data to Risk-Informed Decisions Through Bridge Model Updating
By Dr. Iris Tien, Georgia Institute of Technology, September 25, 2019

A Performance-Based Approach for Loading Definition of Heavy Vehicle Impact Events
By Dr. Anil Agrawal, The City College of New York, June 5, 2019

VIEW COMPLETE LIST OF WEBINARS
scholarsmine.mst.edu/inspire_webinars

INSPIRE Supports Boy Scout Invention Jamboree in Missouri

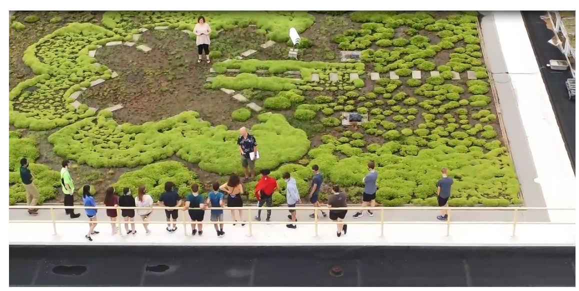
On October 2, 2021, the INSPIRE UTC of Missouri S&T provided support for the Boy Scout Jamboree Event held at the Lake of the Ozarks scout reservation that is the camping home of the Boy Scout of America Great Rivers Council. This event is committed to helping scouts, students and adults to understand business, manufacturing and production, leadership, marketing, creativity, and most importantly how to serve the community using what they learn. The Invention Jamboree has been held biennially since 2019. The Jamboree event is very influential and attracted a total 280 people signed up for the event this year with over 300 people on camp including staff and volunteers.

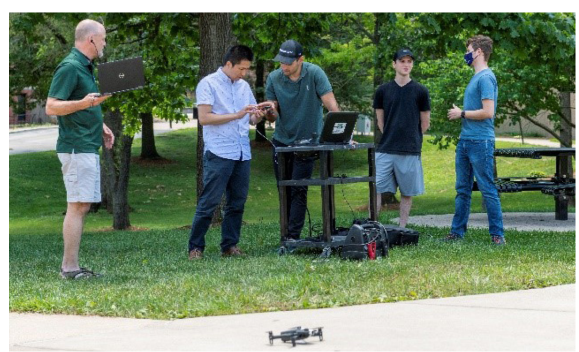
Based on the invention and leadership, the INSPIRE UTC was invited by Scout leader Dr. Jeanne Sinquefield to present our innovative bridge inspection technologies. The technologies with the platform of robots and drones developed by the Center were successfully demonstrated via live demo, videos, and actual operation by Scouts. The Scouts and their parents learned about the center's research, real application status, and the process of training and operating the advanced robots/drones. This event also allowed the Center to make new friends and share ideas between colleagues.

Pictured above, from left to right, Joseph Ressel, Maria Alvarado, Dr. Jeanne Sinquefield, Dr. Lujiun Li, Dr. Haibin Zhang

CII Participates in Jackling Introduction to Engineering

On June 22 and July 12, 2021, the Department of Civil, Architectural and Environmental Engineering at Missouri University of Science and Technology hosted the Jackling Introduction to Engineering summer camp. A research team at the Center for Intelligent Infrastructure (CII) led by Dr. Genda Chen and Dr. Liujun Li was invited to introduce the state-of-the-art robotics and sensing technologies for the novel civil, architectural and environmental engineering applications including infrastructure inspection and preservation, building energy efficiency, green roof concept implementation, plant heat stress assessment, etc. The students were introduced to a variety of engineering fields with demonstrations and activities related to each discipline. Students learned about what engineers do, what tools they use and how the various engineering fields affect everyday life.





The CII team launched the Anafi drone with visible and thermal dual sensing capability and brought a bird's eye view of the entire campus to the students while autonomously scanning the green roof to show the temperature difference between the green roof (with plants growing on the top), the white roof and the black roof, which intuitively visualizes the heat stress conditions of different objects, such as plants, air condition fan, cooling pipeline, building structures, etc. Dr. Joel Burken, the Department Chair walked through the green roof and explained the green roof concept as well as its implementation for the building's energy conservation and environmental benefit. The CII team provided a great opportunity for future students to gain exposure to the latest robotics, drone, remote sensing and data visualization technologies with which they will potentially engage in the future.

For more information, visit: futurestudents.mst.edu

KDC Motivates Young Minds in Robotics and STEM

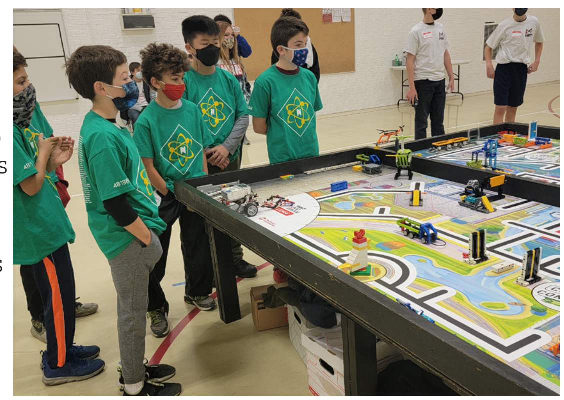
As of November 15, 2021, the Kaleidoscope Discovery Center (KDC) is supporting robotics and engineering programming that reaches over 265 students weekly through the FIRST Lego League and the Missouri Future City Competition. We are so grateful to be selected to receive support from the UTC INSPIRE grant! This past year has been a year of stabilizing and rebuilding for many in our region and we are delighted to be a part of this endeavor.

The FIRST Lego League (FLL) program now reaches a total of 65 students in Missouri weekly with robotics support ranging from 1st – 8th grade for Dent R3, Newburg, Vienna, and leads three programs in Rolla including a homeschool group at the KDC Robotics Room weekly. COVID protocols remain in place with use of masks, frequent hand washing, and social distancing. While not all teams are ready to participate, in-person Covid-aware competitions began with the November 13 qualifier in Rolla which noted the advancement of two local FLL Challenge teams to regional competition. Kaleidoscope volunteers and staff supported this event both in coaching and judging capacities.

The Missouri Future City program now reaches over 200 students weekly raising familiarity of engineering concepts and supporting creative problem solving among 6th – 8th grade students. This past year the teams were challenged to create a sustainable city on the Moon. Both the Missouri and the National Future City Competitions were conducted virtually including teams from Egypt, China and Kenya. Altero Domi, the Missouri team from St. Clair Middle School, placed third in the national competition! Members of the INSPIRE UTC group participated in the virtual competition also selecting Altero Domi as their INSPIRE award winners. Already this year, there are twenty teams across the state that meet weekly and are preparing their creative engineering solutions to create a waste free city!

Recognizing the gap in teacher/coach/parent coding expertise, the first robotics build and code workshop was held in September 2021. This knowledge shortage for the adults-in-charge has been identified as an education barrier in promoting STEM activities to students. The half-day workshop required that adult mentors build and program their own robots from the first Lego brick to the last line of code. Supporting all educators that promote STEM education to our students is one of the Kaleidoscope's primary objectives.

On the horizon? The FIRST Lego League Explore Competition will be hosted in March 2022 in conjunction with the Rolla high school robotics teams which marks the first time this event will be held in our region! The competition is geared toward 1st-4th grade students and allows for Missouri S&T and community robotics-related organizations to showcase the exciting work that has been accomplished in this field.



Pictured above, Altero Domi, the Missouri team from St. Clair Middle School

For more information, visit: thekaleidoscope.org/first-robotics

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Lisa Winstead, INSPIRE UTC Program/Project Support Coordinator

UPCOMING EVENTS

December 14, 2021
Webinar: Hyperspectral Imaging and Data Analytics for Civil Infrastructure Inspection, Missouri S&T
inspire-utc.mst.edu/webinars/

January 9-13, 2022
The 101st Transportation Research Board Annual Meeting, Washington D.C.
www.trb.org/AnnualMeeting/AnnualMeeting.aspx

March 6-10, 2022
SPIE Smart Structures + NDE 2022, Long Beach, CA
spie.org/conferences-and-exhibitions/smart-structures-nde?SSO=1

March 15-17, 2022
The 13th International Workshop on Structural Health Monitoring (IWSHM), Stanford University, CA
iwshm2021.sites.stanford.edu/about-iwshm-2021

inspire-utc.mst.edu/events