Greetings friends and colleagues! Since our last issue, a lot has happened at the INSPIRE UTC. We completed our annual external proposal review and funding recommendations were made for Year 3 projects. New projects will include Bridge Inspection Robot Deployment Systems (BIRDS), led by Missouri S&T, and Autonomous Ultrasonic Thickness Measurement by a Magnet-Wheeled Robot, led by Georgia Institute of Technology.

INSPIRE continues to seek ways to engage students in transportation research. We recently launched a new undergraduate research program at Missouri S&T for under-represented first year students. This program offers a unique opportunity for new students to get involved with INSPIRE research projects their first year on campus. As this semester end nears, we look forward to our summer research activities, which will include student research exchanges between consortium members, The City College of New York and Georgia Institute of Technology, University of Nevada, Las Vegas and University of Nevada, Reno and Lincoln University and Missouri S&T.

This summer we also plan to hold our annual meeting in conjunction with the 9th International Conference on Structural Health Monitoring of Intelligent Infrastructure (SHMII-9) in St. Louis, Missouri, August 4-7, 2019. SHMII-9 provides a forum for the exchange of ideas, knowledge sharing, and technology-need matchmaking in the global structural health monitoring (SHM) community. It will serve as a unique venue to showcase the technologies and achievements in transportation infrastructure, demonstrate the practical value of SHM research, and raise the public awareness on the need for further SHM research and applications. INSPIRE UTC graduate students will have the opportunity to interact with other faculty and students and industry leaders at this event. In addition, the INSPIRE UTC, in partnership with the Missouri Department of Transportation, will give a demonstration at a St. Louis bridge site to show how the advanced technology currently being developed by INSPIRE can be applied in practice to improve current bridge inspection methods.

This newsletter issue focuses on the sensing and nondestructive evaluation research conducted by INSPIRE. This issue also introduces the research data management services provided by Missouri S&T Scholars’ Mine, and introduces new members of our research team.

We invite you to read the featured articles and news of the INSPIRE UTC, and visit our website at inspire-utc.mst.edu for additional information about our center’s research, education, outreach and workforce development efforts.

Sincerely,

Genda Chen, Ph.D., P.E., F. ASCE, F. SEI
Professor and Robert W. Abbett Distinguished Chair in Civil Engineering
Director, INSPIRE University Transportation Center
Missouri University of Science and Technology
Missouri S&T faculty attend TRB meeting

The INSPIRE UTC director and other members of the Civil, Architectural, and Environmental Engineering department at Missouri S&T attended the 2019 Transportation Research Board (TRB) Annual Meeting on January 13-17, 2019 in Washington, D.C. This program attracts more than 13,000 transportation professionals from around the world.

Pictured from left to right below are Dr. Hongyan Ma, assistant professor in materials engineering and INSPIRE research investigator, Dr. Genda Chen, professor in structural engineering and INSPIRE UTC director, Dr. Magdy A. Abdelrahman, professor in materials engineering, and Dr. Yi Bao, former Ph.D. graduate in structural engineering, who is currently assistant professor at Stevens Institute of Technology.

DEAN’S MESSAGE

We are at the forefront of a revolution in robotics in which dull, dirty, and dangerous tasks will no longer have to be performed by humans. About two decades ago, I had the pleasure to work with a group of creative people at DARPA, and the drones we imagined then have become commonplace today. INSPIRE will lead the way in merging advanced robotics with highly capable aerial vehicles to revolutionize the way in which infrastructure inspection and maintenance is performed. In two decades we will look back at the visionary days at S&T when these seeds were planted. Research is all about making the visionary ideas of today the commonplace of tomorrow. I am delighted to see all the great work Dr. Chen and his INSPIRE team have achieved and look forward to another year of groundbreaking achievements. INSPIRE continues to inspire us all.

Richard Wlezien, Ph.D.
Vice Provost and Dean
College of Engineering and Computing

For more information visit: trb.org/AnnualMeeting/AnnualMeeting

INSPIRING NEWS

Recent news coverage brings visibility to INSPIRE research and the importance of its application to solving critical infrastructure needs.

Watch both interviews online:

- KY3 NEWS: https://bit.ly/2Ua0cRk
Blake Hament named 2019 UTC Outstanding Student of the Year

Blake Hament, a doctoral student and research assistant at the University of Nevada, Las Vegas (UNLV) Drones and Autonomous Systems Lab (DASL), has been named a University Transportation Center Outstanding Student of the Year by the U.S. Department of Transportation (DOT).

His Research Advisor is Dr. Paul Oh, Lincy Professor for Unmanned Aerial Systems at UNLV, and Associate Director and Principal Investigator at the INSPIRE University Transportation Center, which examines the inspection and preservation of infrastructure through robotic exploration. Blake’s role in Dr. Paul Oh’s INSPIRE project has been to model reaction forces and torques from expelling compressed fluid from a hose mounted on an unmanned multirotor vehicle. This modeling can be used to compensate for hose effects in real-time operation and thus enable the use of UAV for infrastructure cleaning.

Blake’s research interests span robotic perception and control and mixed reality. In addition to INSPIRE he has worked on several projects related to humanoid computer vision, uneven terrain path-planning, heterogeneous robot collaboration, and virtual reality snowboard training.

Hament received the award in January 2019 at the annual winter meeting of the Transportation Research Board in Washington D.C. The award criteria includes accomplishments in areas such as technical merit and research capability, academic performance, and leadership.

INSPIRE launches freshmen research program

The INSPIRE UTC recently announced plans to implement a Freshmen Undergraduate Research Program in 2020. This new program provides support for up to three under-represented freshman each year who enroll at Missouri S&T. Selected students will participate in an INSPIRE research project under the direction of a Missouri S&T faculty advisor. Projects start at the beginning of the fall semester and end at the conclusion of the following spring semester.

For more information email: inspire-utc@mst.edu
INSPIRE UTC poised to help address Missouri’s bridge repair needs

Missouri Gov. Mike Parson’s plan to release bond funds to support bridge repair across the state comes as welcome news to researchers at Missouri S&T, home to a federal initiative to develop new robotic tools to inspect and preserve bridges and other infrastructure.

Missouri S&T researchers are in the midst of a five-year effort to develop new technologies to inspect and maintain bridges and portions of highway. The U.S. Department of Transportation grant provides $1.4 million a year to fund a Tier 1 University Transportation Center at Missouri S&T known as INSPIRE, which stands for Inspecting and Preserving Infrastructure through Robotic Exploration.

“The work underway through our INSPIRE program can benefit similar statewide initiatives to repair our aging infrastructure in the future,” says Dr. Genda Chen, the Robert W. Abbott Distinguished Chair in Civil Engineering at Missouri S&T and director of INSPIRE.

During his State of the State Address Wednesday, Jan. 16, Missouri’s governor announced his proposal to use bond proceeds worth $351 million to repair an estimated 250 smaller bridges across the state. Many of the bridges are in dire need of repair, says Chen. He points to the American Society of Civil Engineers’ Infrastructure Report Card, which gives Missouri’s bridges a score of C. One out of every eight bridges in Missouri is considered “structurally deficient,” the score-card notes, and the Missouri Department of Transportation has identified 4,800 bridges in need of repair across the state.

The INSPIRE UTC researchers can help by developing new robotic tools to inspect bridges with reduced impact on traffic flow. The work involves unmanned aerial vehicles (UAVs) as well as robots capable of crawling up the side and underside of a bridge to inspect pillars or bridge decks. “We are developing robotic arms for both flying and climbing unmanned vehicles to inspect and maintain bridges and other transportation infrastructure,” Chen says. “Once this technology is developed and in use, we will not need to close traffic for bridge inspection and preservation.”

In addition to inspecting bridges, the robotic arms could apply sealant or paint to bridge sections, all guided remotely by engineers who monitor the work on a screen and visually verify the results as needed. Chen envisions equipping the robots with sensors and microwave cameras capable of detecting potential issues inside bridge beams and decks before they become problematic. “With the arrival of the robotic era, we expect bridge inspection to be reinvented and transformed into a faster, cheaper, safer and more consistent process,” Chen says.

Posted January 15, 2019 - Missouri S&T News and Events

“With the arrival of the robotic era, we expect bridge inspection to be reinvented and transformed into a faster, cheaper, safer and more consistent process.”

- Dr. Genda Chen
New student joins UNR’s Advanced Robotics and Automation Lab

MEET SON NGUYEN, UNIVERSITY OF NEVADA, RENO

**INSPIRE Project:** Climbing Robots with Automated Deployment of Sensors and NDE Devices for Steel Bridge Inspection. **Research Advisor:** Dr. Hung La

Son Nguyen received a B.S. in mechatronic from Military Technical Academy, Ha Noi, Viet Nam, where he worked on robot arm design and Quadcopter related to the flight control problem. Son Nguyen gained a M.S in control engineering and automation from Ho Chi Minh City University of Transport, Ho Chi Minh, Viet Nam.

Son is currently a Ph.D. student and research assistant at the University of Nevada, Reno’s Advanced Robotics and Automation Lab (ARA). Son’s role in Dr. Hung La’s INSPIRE research project is to design and fabricate a climbing robot for steel bridge inspection. If successful, the climbing robot can be applied to a variety of steel bridge inspections with different structures and surface contours. The robot can collect visual and nondestructive evaluation data and do specialized examinations.

Son’s research interests span robotic design and autonomous control. In addition to INSPIRE research, he has worked on several projects related to CNC manufacturing, pipe inspection robot, helicopter 2DOF, and life-ring drone delivery system.

For more information visit: ara.cse.unr.edu

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Visiting scholars join INSPIRE research team

**Paola Manhães:** Missouri S&T. **Research Advisor:** Dr. Genda Chen

Paola Manhães, a visiting scholar at Missouri S&T from the Pontifical Catholic University of Rio de Janeiro, Brazil recently joined the INSPIRE research team. Mrs. Manhães holds B.S. and M.S. degrees in Civil Engineering (Geotechnics) from the State University of Norte Fluminense in Brazil. She has carried out research on centrifuge physical modelling, X-ray microtomography and digital image processing. Currently, Mrs. Manhães is researching structural health monitoring of reinforced concrete structures.

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**Zepeng Chen:** Missouri S&T. **Research Advisor:** Dr. Genda Chen

Mr. Zepeng Chen is a visiting student intern at Missouri S&T from Jinan University in Guangzhou, China. Mr. Chen received a B.S. degree in engineering from Jinan University in July 2014. He then received an opportunity to further his research in structural damage detection (SDD) as a post-graduate student.

Mr. Chen is currently enrolled in the program of successive post-graduate and doctoral programs of study at Jinan University under the supervision of Dr. Ling Yu. Mr. Chen’s focus is on model updating methods in SDD and his interests include soft computing methods such as intelligent algorithms, deep learning, and Bayesian theories. Mr. Chen has completed work related to the improvement of particle swarm optimization in SDD, and damage-sensitive features extraction based on sparse representation methods. His research advisor at Missouri S&T is Dr. Genda Chen.
INSPIRE co-sponsors technical writing seminar series

In March 2019, a series of two technical writing seminars were held that engaged a total of 164 participants. The seminars were co-sponsored by the Center for Environmentally Sustainable Transportation in Cold Climates (CESTiCC) at the University of Alaska Fairbanks, the International Association of Chinese Infrastructure Professionals (IACIP), and the INSPIRE University Transportation Center (INSPIRE UTC). View archived seminars at: scholarsmine.mst.edu/inspire_invited_speakers.

SIX KEY ELEMENTS OF HIGH QUALITY TECHNICAL WRITING

Presented: March 8, 2019
Speaker: Xianming Shi, Ph.D., P.E., Associate Professor, Washington State University

Abstract
What is the definition of “high quality”, when it comes to technical writing? What are the key elements that differentiate high-quality technical writing from the technical writing that is less effective in communicating the message? This webinar stems from the presenter’s observations and personal thoughts over the last decade or two, as an active researcher, a mentor, and a teacher in the engineering community. This webinar will be organized around six key elements or keywords identified by the presenter, i.e., innovation, engaging, hypothesis, logic, synthesis, and details.

GENERAL GUIDES TO PUBLISH WELL-WRITTEN TECHNICAL PAPERS

Presented: March 22, 2019
Speaker: Jie Han, Glenn L. Parker Professor of Geotechnical Engineering, F. ASCE, The University of Kansas.

Abstract
Technical papers are one of the important means to disseminate research results to the scientific and engineering community. They should be well written and make original contributions to the body of knowledge. Most technical papers are published after a peer-review process, which may be short or long, depending on many factors including the quality of technical contents, presentation, responses to review comments, and revisions. This webinar will first provide a brief overview of a typical publication process, key requirements for technical papers, and standards of acceptance and then focus on common issues in paper writing (including paper presentation) with general guides to overcome these issues.
Liang Fan receives two prestigious awards for academic and professional excellence

Liang Fan, a doctoral student and INSPIRE UTC research assistant at Missouri S&T, is the recipient of two prestigious awards for excellence in academic success, scholarly contributions, professional experiences and service to the department, university and community. Fan received the Stueck Outstanding Civil Engineering Senior Award at the annual Academy of Civil Engineers’ banquet on April 25, 2019. He was also selected by the Missouri S&T Dean of the College of Engineering and Computing to be a recipient of the College of Engineering and Computing (CEC) PhD Scholar Award. Fan will receive the PhD Scholars Award at the CEC reception on May 16, 2019. Both of these selective, distinct honors speak very highly of Fan’s contributions.

At Missouri S&T, Fan has participated in six externally funded research projects in the areas of pipeline corrosion protection with enamel coating, pipeline corrosion detection using fiber optic sensors, bridge deterioration evaluation using fiber optic sensors, hyperspectral and microwave imaging, and fire-induced building deterioration assessment using fiber optic sensors. He has mastered excellent skills in corrosion and distributed fiber optic sensing research, and has recently supported new research initiatives using hyperspectral and microwave imaging. Due to his in-depth knowledge in a wide range of research fields surrounding the theme topic of corrosion, he has helped train and guide a new INSPIRE Ph.D. student in a hyperspectral imaging project. His research advisor is Dr. Genda Chen.
WIRELESS STRAIN MEASUREMENT USING AN ANTENNA SENSOR

As the number of aging steel bridges continues to grow every year, there is an increasing demand for low-cost wireless sensors that can monitor the stress concentration and crack development in these bridges. In this project, a group of researchers at the Georgia Institute of Technology attempts to develop low-cost wireless antenna sensors for field deployment.

An antenna sensor can wirelessly measure strain on a structure. Bonded to the surface of a base structure, the antenna sensor deforms when the structure is under strain, causing the antenna's electromagnetic resonance frequency to change. This resonance frequency change can be wirelessly interrogated and recorded by a reader through electromagnetic backscattering.

When interrogated wirelessly as illustrated in Fig. 1, a radio frequency identification (RFID) chip on the sensor, operating in the 900 MHz ISM frequency band, harnessed a small amount of energy from the interrogation signal and responds to the reader. The resonance frequency change identified by the reader is then used to determine the strain applied to the structure.

Fig. 1. Wireless interrogation of an antenna sensor with an RFID chip harnessing a tiny amount of interrogation energy and responding to the reader.

Our previous research developed a prototype sensor that demonstrated the operating principle for strain sensing. However, it was discovered that the dielectric constant of the polymer substrate in the antenna sensor varies under temperature fluctuations. Because the change in dielectric constant affects antenna resonance frequency, the change affects strain measurement accuracy.

In this project, we first developed an antenna sensor on a new substrate material that has more stable dielectric constant under temperature fluctuations. The new sensor prototype was then placed side by side with the old prototype, and tested under ambient conditions, as shown in Fig. 2. It was observed over a period of five hours that the change in resonance frequency of the new sensor was reduced by five times in comparison with the old sensor, demonstrating a significantly improved thermal stability in outdoor application setting.

Further laboratory tests were conducted to characterize mechanical behaviors of the involved components, including the sensor substrate, the bonding adhesive, and the aluminum base. Electromagnetic experiments were also conducted to characterize how the dielectric constant of the substrate changed with the applied strain.

The experimental results were then used to calibrate a variety of mechanical and electromagnetic simulation parameters for all sensor components. The calibration was formulated as a mathematical optimization problem, attempting to minimize the difference between theory and reality.

Fig. 2. Outdoor test setup of two antenna sensor prototypes.

"As the number of aging steel bridges continue to grow every year, there is an increasing demand for low-cost wireless sensors that can monitor their stress concentration and crack development."

With the calibrated mechanics and electromagnetics parameters, a multi-physics model of the antenna bonded on an aluminum base structure can be constructed. The close-up view in Fig. 3 shows that the antenna sensor consists of a polymer substrate sandwiched between two copper claddings. The RFID chip is soldered on the top cladding.
INSPIRE NEWSLETTER | inspire-utc.mst.edu

INSPECTING AND PRESERVING INFRASTRUCTURE THROUGH ROBOTIC EXPLORATION

ABOUT THIS PROJECT
Led by Dr. Yang Wang, Associate Professor Civil and Environmental Engineering at the Georgia Institute of Technology, the Battery-Free Antenna Sensors for Strain and Crack Monitoring project is part of the INSPIRE (INSpecting and Preserving Infrastructure through Robotic Exploration) UTC Research Program. For more information on this and other INSPIRE UTC projects, please contact Dr. Genda Chen, Professor and Abbett Distinguished Chair in Civil Engineering and Director of the INSPIRE UTC at Missouri University of Science and Technology, at inspire-utc@mst.edu or (573) 341-6114.

FOR MORE INFORMATION CONTACT:

Dr. Yang Wang,
Associate Professor, Civil and Environmental Engineering
Georgia Institute of Technology
(404) 894-2278| yang.wang@ce.gatech.edu

Mechanics analysis was first performed to study how the sensor, bonded on a base structure, deformed as the base (being monitored) underwent strain/stress. The deformed shape of the antenna sensor was then used to perform the electromagnetic simulation of the antenna, providing its electromagnetic resonance frequency under strain conditions. This mechanics-electromagnetics simulation process allowed researchers to study and improve the sensor performance prior to fabrication.

Once fabricated, the antenna sensor was tested under tensile and compressive strains to verify its performance. In both simulations and laboratory experiments, the antenna sensor was demonstrated to successfully measure tens to thousands of micro-strains.

Finally, emulated crack tests were performed with the antenna sensor. To this endeavor, two rigid slabs were placed side by side to form one plane on which the sensor was bonded, spanning over the two slabs. An experimental apparatus was designed and built to control gradual opening between the two slabs. Test results demonstrated that the sensor wirelessly responded to the reader even when the two underneath slabs was separated by 0.04 inches.

Although not required for responding to the reader, onboard battery power on an antenna sensor can improve the sensor performance. Therefore, a dual-mode prototype was developed to allow the sensor operation to benefit from battery power, when available, in active mode. To this end, a small circuit with a credit-card size solar panel and a rechargeable coin cell battery was designed. If the battery is charged by solar power, the sensor operates in the active mode, providing stronger response to the reader. When the battery is drained up, the sensor automatically falls back to the passive mode, i.e. receiving operational energy completely from reader interrogation as shown in Fig. 1. Once fabricated, the dual-mode sensor prototype will be validated experimentally.

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**Fig. 3.** Multi-physics simulation model of an antenna sensor bonded on an aluminum base structure with a close-up view of the sensor cross section.

**Fig. 4.** An experimental apparatus of two side-by-side rigid slabs that can be separated in a control fashion along the crack opening line.
This project aims to develop and validate smart rocks with embedded magnets that can automatically roll down the bottom of their surrounding scour hole under strong current, and that can be positioned through remote sensing with a magnetometer installed on an unmanned aerial vehicle (UAV). Smart rocks as shown in Fig. 1 can be deployed prior to a flood event and, as a field agent, are directly involved in the process of scour. Each rock is composed of one or more permanent magnets with an aligned gravity-controlled polarization direction and a spherical fiber-reinforced concrete encasement. Its design is based on the critical velocity of water flow.

Smart rocks can be located from a spatial distribution of their surrounding magnetic field measurements. The difference in two sets of measurements over time represents the movement of the smart rocks or the evolution of the scour hole during that period. The maximum scour depth is critical to the evaluation of foundation stability.

The main focus of this project is to: (i) design, build, and test a UAV with a ground-referenced global positioning system (GPS) and a 3-axis magnetometer (control system and sensor head), (ii) investigate the effect of UAV operations on magnetic field measurements, (iii) evaluate the localization accuracy of one, two, and three smart rocks, and (iv) demonstrate the field performance of smart rocks for scour monitoring at bridge sites.

To make magnetic field measurement practical, a 3-axis magnetometer and a GPS are installed on a UAV, as indicated in Fig. 2. This setup allows for a rapid collection of dense intensity and coordinate data at a bridge site. The large data set will improve the accuracy of smart rock localization and movement prediction.
To quantify the GPS accuracy, both static and dynamic tests were conducted at Ber Juan Park in the City of Rolla. For static tests on a flat ground, a total of nine points with 0.5 m spacing were selected in a vertical plane as positioned in Fig. 4. Their ground-truth coordinates were measured from a total station. The total station is located about 10 m away from the origin of the test setup as shown in Fig. 4 (not-to-scale).

The UAV with GPS was placed at one test point at a time, as shown in Fig. 4. Its GPS coordinate was compared with that obtained from the total station. The positioning error as indicated in Fig. 5 is the lowest at the test points closer to the total station since the accuracy of ground truth data decreases with measurement distance. Specifically, the mean errors in positioning are 4% and 8% for horizontal and vertical coordinates, respectively.

(Continued on page 12)

“Smart rocks can be located from a spatial distribution of their surrounding magnetic field measurements. The difference in two sets of measurements over time represents the movement of the smart rocks or the evolution of the scour hole during that period. The maximum scour depth is critical to the evaluation of foundation stability.”
For dynamic tests, the UAV was locked at 5 m above the ground at a constant speed of 1 m/sec to 5 m/sec. The test setup included an accelerating distance of 10 m and a constant-speed distance of 20 m. When the UAV reached the targeted speed, the time flying over a 20 m distance was recorded. With the known UAV speed, the GPS measured distance was calculated and compared against the 20 m reference horizontal distance. The horizontal measurement error was found to increase almost linearly with the UAV speed. To keep within 5% error, a UAV speed of 2 m/sec is recommended for field works at bridge sites.

The smart rock deployed near Pier 7 of the Roubidoux Creek Bridge was located successfully and satisfactorily. Its coordinate predicted from the localization algorithm and the measured coordinate from a total station as well as their difference (square-root-of-the-squared error) are presented in Table 1. The UAV- and crane-based sensing accuracies (moving vs. fixed measurement platform) are in general agreement, giving a maximum error of 0.36 m. With the UAV-based measurement, the rock positioning error appears decreasing over time, which is mainly due to the improvement in GPS positioning of the UAV. Note that the crane-based measurements were taken during the previous project funded through the USDOT Commercial Remote Sensing and Spatial Information Technologies Program. They required traffic control and closure during field tests.

The movement of the smart rock during the six field tests is displayed in Fig. 6 on a three-dimensional contour map of the riverbed prepared at the end of the 2nd field test. In particular, the smart rock sank by 0.4 m during the Feb. 25, 2019, flood that occurred between the 5th and 6th field tests.

Table 1. Comparison of smart rock positioning accuracies between crane- and UAV-based sensing.

<table>
<thead>
<tr>
<th>Monitoring Method</th>
<th>Predicted Coordinate</th>
<th>Measured Coordinate</th>
<th>ERROR (m)</th>
</tr>
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<td>$Z_m$</td>
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<tr>
<td>UAV (6th)</td>
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<td>25.60</td>
<td>-3.16</td>
</tr>
</tbody>
</table>

About this Project
Led by Dr. Genda Chen, Professor and Abbett Distinguished Chair in Civil Engineering and Director of the INSPIRE (INSpecting and Preserving Infrastructure through Robotic Exploration) UTC at Missouri University of Science and Technology, the UAV-enabled Measurement for Spatial Magnetic Field of Smart Rocks in Bridge Scour Monitoring project is part of the INSPIRE UTC Research Program. For more information on this and other INSPIRE UTC projects, please contact Dr. Chen at inspire-utc@mst.edu or (573) 341-6114.

For More Information Contact:

Genda Chen
Professor and Robert W. Abbett Distinguished Chair in Civil Engineering
Missouri University of Science and Technology
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Meet us in St. Louis for SHMII-9!

You are cordially invited to attend the 9th International Conference on Structural Health Monitoring of Intelligent Infrastructure (SHMII-9). SHMII-9 is focused on “Transferring Research into Practice” and calls for the attention and wide participation from researchers, engineers, owners and regulators. The program will include:

**August 4, 2019 – Pre-Conference Short Course**
Structural Health Monitoring Using Fiber Optic Sensors
A course for civil engineers, researchers, managers and owners of infrastructures

**August 5-7, 2019 – Full Conference**
- Technical keynote lectures, invited lectures, podium sessions, student poster competitions, student-mentor career path sessions, panel discussion(s)
- Technical tours – includes demonstrations of advanced robotic and sensing technologies on real-world bridges
- Exhibit/Sponsor – Don’t miss unique opportunities to partner with SHMII-9 as a sponsor or to reserve your exhibit space
- Student Poster Session – Showcase your research, exchange knowledge and ideas, and engage with industry leaders

**Early Bird Conference Registration Ends May 24, 2019**: shmii-9.mst.edu

**Over 400 abstracts accepted in four tracks:**
- Research & Development
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- Special Sessions

**Sponsorship & Exhibition Opportunities**
- Sponsorship packages available at platinum, gold, and silver levels.
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For full details, visit: shmii-9.mst.edu/sponsors.

**QUESTIONS?** Our team is available to assist you!

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**Conference Venue - Hyatt Regency St. Louis at The Arch**
All conference activities will be held in the Hyatt Regency St. Louis at The Arch. Located in the heart of downtown St. Louis, the Hyatt is just steps from the iconic Gateway Arch – you won’t want to miss the newly renovated arch grounds and museum depicting America’s westward expansion and the explorers, pioneers and rebels who made it possible.

stlouisarch.hyatt.com
Scholars’ Mine is the institutional repository for the Missouri University of Science and Technology (Missouri S&T). Scholars’ Mine provides access to the digital scholarly and cultural resources created by the university community. In Scholars’ Mine you will find published research by our faculty and graduate students, as well as professional research profiles featuring our faculty contributions to their fields of study. Our digital world both shares and increases the impact of the full range of faculty scholarship, from primary materials and research datasets to teaching tools and working papers. Faculty and the institution benefit when research gets noticed.

Scholars’ Mine began in 2006 with less than 10,000 research objects and about 100,000 global downloads per year. Today, Scholars’ Mine contains over 41,000 research objects and 1.5 million global downloads each year. Scholars’ Mine also contains a diversity of content including faculty research and creative works, conference proceedings, student research and creative works, locally published journals, and research and other content related to several campus research centers and laboratories.

Scholars’ Mine hosts various content from the INSPIRE UTC including webinars, publications, newsletters, and meeting minutes and reports. Additionally, Scholars’ Mine will be hosting research data generated through INSPIRE research activities. Scholars’ Mine provides INSPIRE with increased global visibility and showcases ongoing research activities and projects.

In preparation to host research data, Scholars’ Mine applied for and received a CoreTrustSeal Certification in April 2018. This certification conforms to the DOT public access plan for DOT sponsored research. CoreTrustSeal provides a core level certification based on The World Data System of the International Science Council and the Data Seal of Approval (DSA-WDS) Core Trustworthy Data Repositories Requirements catalogue and procedures. Having received the CoreTrustSeal, Scholars’ Mine conforms to the core characteristics of a trustworthy data repository and is considered a trusted repository for housing research data.

"Scholars’ Mine provides INSPIRE with increased global visibility and showcases ongoing research activities and projects."

Roger Weaver, Scholarly Communications Librarian, Library & Learning Resources, Missouri S&T

For more information, visit: scholarsmine.mst.edu
Scholars’ Mine provides a permanent online presence for the INSPIRE-UTC, enabling the sharing of INSPIRE faculty research, newsletters, webinars and progress and performance reports in an open access environment.

Within Scholars’ Mine, a gallery of INSPIRE UTC faculty from S&T is presented, with individual author profiles for each member. These profiles showcase publications, research interests, honors and awards, professional memberships and more.

"Benefits of inclusion in Scholars’ Mine include a global readership and a connection to other research in bepress’ network of institutions."

The INSPIRE UTC’s first Annual Meeting, held in August 2018, is archived in Scholars’ Mine. The full schedule of events is available, with downloadable presentations. These events are also browsable by topic. The INSPIRE graduate student poster session is also included, as is the Center’s recent Pedestrian Bridge Test demonstration with photos.

Benefits of inclusion in Scholars’ Mine include a global readership and a connection to other research in bepress’ network of institutions. Below is a map of INSPIRE downloads. Two of the most downloaded works are from the webinar series: Drone-Enabled Remote Sensing for Transportation Infrastructure Assessment a December 2017 webinar by Colin Brooks; and Lab-on-Sensor for Structural Behavior Monitoring: Theory and Applications, a September 2017 webinar by Dr. Genda Chen, INSPIRE UTC Director.

Visit INSPIRE’s page at: scholarsmine.mst.edu/inspire-utc
BATTERY-FREE WIRELESS STRAIN MEASUREMENT USING AN ANTENNA SENSOR

**Presented:** March 6, 2019

**Speaker:** Dr. Yang Wang
Associate Professor, Civil and Environmental Engineering, and Adjunct Professor, Electrical and Computer Engineering
Georgia Institute of Technology

ASSISTIVE INTELLIGENCE (AI): INTELLIGENT DATA ANALYTICS ALGORITHMS TO ASSIST HUMAN EXPERTS

**Presented:** January 30, 2019

**Speaker:** Dr. Zhaozheng Yin
Associate Professor and St. Clair Fellow
Computer Science Department
Missouri University of Science and Technology

A PERFORMANCE-BASED APPROACH FOR LOADING DEFINITION OF HEAVY VEHICLE IMPACT EVENTS

**Presented:** June 5, 2019, 11:00 am (Central)

**Speaker:** Dr. Anil K. Agrawal
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**Register:** inspire-utc.mst.edu/webinars

Based on bridge failure data compiled by New York State Department of Transportation, collision, both caused by vessel and vehicles, is the second leading cause of bridge failures after hydraulic. Current AASHTO-LRFD (2012) recommends designing a bridge pier vulnerable to vehicular impacts for an equivalent static force of 600 kips (2,670 kN) applied in a horizontal plane at a distance of 5.0 feet above the ground level. This research presents a performance-based approach for designing a bridge pier subject to impacts by tractor-semi-trailer weighing up to 80,000 lb based on an extensive investigation using finite element model of a tractor-semi-trailer in LS-DYNA. In order to ensure the reliability of the proposed approach, parameters of concrete model were calibrated using small-scale impact test and were validated using a large scale test. Mechanics and modes of failure of bridge bents during vehicular impacts were verified through pendulum impact test on a large scale model of three-column bent system. A performance-based approach in terms of shear distortion, plastic rotation and demand / capacity (D/C) ratio has been proposed for the design of bridge piers vulnerable to heavy vehicle impacts.
CCNY TECHNOLOGY TRANSFER

Dr. Jizhong Xiao of The City College of New York (CCNY) received an NSF I-Corps grant entitled “SenseTech: Non-Destructive Evaluation (NDE) of Aging Infrastructures by Integration of Visual Inspection with 3-D Imaging of Ground Penetrating Radar (GPR)”.
CCNY will organize I-Corps lectures and workshops, and devote at least 15 additional hours per week for customer discovery to commercialize the technology.

RECENT KEYNOTE/INVITED PRESENTATIONS

- “Sensor-enhanced Analysis and Behavior of Steel Beams in Fire,” 5th World Congress and Exhibition on Construction and Steel Structure, Los Angeles, CA, October 5-6, 2018. (Genda Chen)

WEBINAR ARCHIVES

2019
- Battery-Free Wireless Strain Measurement Using an Antenna Sensor
  By Dr. Yang Wang, Georgia Institute of Technology, March 6, 2019
- Assistive Intelligence (AI): Intelligent Data Analytics Algorithms to Assist Human Experts
  By Dr. Zhaozheng Yin, Missouri S&T, January 30, 2019

2018
- Toward Autonomous Wall-climbing Robots for Inspection of Concrete Bridges and Tunnels
  By Dr. Jizhong Xiao, The City College of New York, September 19, 2018
- Climbing Robots for Steel Bridge Inspection and Evaluation
  By Dr. Hung La, University of Nevada, Reno, June 21, 2018
- Microwave Materials Characterization and Imaging for Structural Health Monitoring
  By Dr. Reza Zoughi, Missouri S&T, March 15, 2018

2017
- Drone-Enabled Remote Sensing for Transportation Infrastructure Assessment
  By Colin Brooks, Michigan Technological University, December 13, 2017
- Lab-On-Sensor for Structural Behavior Monitoring: Theory and Applications
  By Dr. Genda Chen, Missouri S&T, September 18, 2017

scholarsmine.mst.edu/inspire_webinars
Team Sanat Kalir wins INSPIRE award at the Missouri State Future City Competition

The second annual Missouri Future City Competition, hosted by the Kaleidoscope Discovery Center, was held January 26, 2019 on the Missouri S&T campus. The INSPIRE UTC provided support for this event, which brings 6th, 7th, and 8th grade students from across the state to participate in the international Future City competition.

Future City starts with a question—how can we make the world a better place? To answer it, students imagine, research, design, and build cities of the future that showcase their solution to a citywide sustainability issue. Past topics included storm water management, urban agriculture, public spaces, and green energy. The 2018-2019 theme was Powering Our Future! Teams designed a resilient power grid for their future city that can withstand and quickly recover from the impacts of a natural disaster.

This year, two members of the INSPIRE research team, Dr. Hongya Qu and Chuanrui Guo of Missouri S&T, served as judges for the event and gave a specialty award on behalf of the INSPIRE UTC. The INSPIRE award is granted to the team whose project design best incorporates structural functionality and feasibility, robustness, and resilience. Special consideration is given to teams who consider the concept of robotic exploration of the city’s infrastructure.

Team Sanat Kalir from St. Clair, Missouri was the recipient of the INSPIRE award, and took 2nd Place in the overall competition. They received an INSPIRE award plaque and a $150 monetary award. Team Sanat Kalir went on to win an award at the national competition in Washington D.C. for their attention to social issues that accompany natural disasters.
INSPIRE supports 2019 FIRST LEGO League Junior Expo event

In February 2019, the INSPIRE UTC provided support for the FIRST LEGO League (FLL) Junior Expo hosted by the Kaleidoscope Discovery Center (KDC) on the Missouri S&T campus in Rolla, MO. FLL Junior introduces students to robotics in grades K-4. The FLL Junior season culminates with an Expo where teams show off what they learned and created. Some teams are invited to display their work at the FIRST LEGO League Junior World Festival Expos, where teams from all over the world meet, share ideas, and have fun. The theme of the 2019 FLL Junior Expo was "Mission Moon", where participating students worked together to find a solution for living on the Moon.

The support provided by the INSPIRE UTC enabled the KDC to provide certificates to reward every student who competed, and will help encourage even more students to take part in FLL Junior in the coming years.

For more information, visit: thekaleidoscope.org/first-robotics
Missouri S&T faculty and students INSPIRE high school students at the NSBE Pre-College Initiative

Faculty and students from the INSPIRE University Transportation Center and Mid-America Transportation Center led a workshop for 40 Missouri high school students at the National Society of Black Engineers (NSBE) Pre-College Initiative (PCI) held February 24 on the Missouri S&T campus.

The workshop was presented by Dr. Ruwen Qin, Associate Professor of Engineering Management and Systems Engineering, Ph.D. students Xinzhe Yuan, Abdullah Alhaj, and Md. Al-Min, and undergraduate student, David Doell. Participants were engaged in a hands-on bridge engineering competition, and visited the Driving Simulation Laboratory for a demonstration of driver’s behavior-related transportation research.

PCI is an on-campus visit program for African-American students who may be considering a future career in math, science, computing or engineering. PCI is sponsored by S&T’s student chapter of the National Society of Black Engineers and the Student Diversity Initiatives department.

For more information, visit: sdi.mst.edu
UNLV ROBOTICS OUTREACH

Research Education for Teachers

The University of Nevada, Las Vegas (UNLV) team has a Research Education for Teachers (RET) grant sponsored by the National Science Foundation (NSF).

For six (6) weeks each summer, regional high school teachers learn about research in big data and robotics. The goal is to integrate such learning into K-12 curricula.

INSPIRE UTC results have been disseminated to four K-12 teachers, learning about LIDAR and data acquisition. Such results have also been introduced to middle school students with the team’s partnership with the local public library’s after-school/weekend STEM programs.

Saturday K-12 Programs

The UNLV team continues to work with the neighboring Clark County Las Vegas Public Library in the Saturday K-12 programs.

Lesson plans include computer-aid-design (CAD), 3D printing, and embedded controllers (Arduino). Additionally, the team serves institutional outreach programs, namely Upward Bound. This program is UNLV’s outreach to middle school students.

Each Saturday, the team conducts hands-on STEM labs. These labs include drone (programming), augmented reality (projection mapping), and embedded control (Arduino).

For more information, visit: inspire-utc.mst.edu/events
UPCOMING EVENTS

TECHNOLOGY TRANSFER

May 23-24, 2019
Invited Presentation: "Data to Risk-Informed Decisions through Bridge Model Updating", by Dr. Iris Tien, Georgia Institute of Technology, HeaMES 2019, Glasgow, UK
weamec.fr/en/blog/record_event/heames-2019

June 5, 2019
INSPIRE Webinar: "A Performance-Based Approach for Loading Definition of Heavy Vehicle Impact Events", by Dr. Anil K. Agrawal, The City College of New York
inspire-utc.mst.edu/webinars

August 4-7, 2019
INSPIRE UTC Special Session, Exhibit and Annual Meeting: SHMII-9 Conference, St. Louis, MO
shmii-9.mst.edu

November 22-24, 2019
Invited Presentation: "Robot-assisted Bridge Inspection and Maintenance", ICRAI 2019 Conference, Singapore
icrai.org

OUTREACH

July 17, 2019
MoDOT Transportation Camp, Missouri S&T, Rolla, MO
modot.org/modot-youth-transportation-conference-ytc

inspire-utc.mst.edu/events