



Fall 2018

## INSPIRE Newsletter Fall 2018

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

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# INSPECTING AND PRESERVING INFRASTRUCTURE THROUGH ROBOTIC EXPLORATION

VOL. 2 | ISSUE 2 | FALL  
INSPIRE-UTC Biannual Publication

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- News
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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.

### CONSORTIUM MEMBERS



## Director's Message

Greetings friends and colleagues! There have been many activities and accomplishments to report since our last issue.

We held our first annual meeting in August 2018 on the Missouri S&T campus. The meeting offered our faculty, students and advisory committee the opportunity to share information about our research progress and its potential impact on the transportation industry. INSPIRE directors held an executive meeting with the External Advisory Committee to review Center progress and performance and provide input to our five-year goals. In addition, INSPIRE gave a demonstration of the micro-wave imaging, ground penetrating radar, and hyperspectral, and thermal imaging technology currently being used to test a pedestrian bridge on the Missouri S&T campus. This bridge test brings us one-step closer to real application of these new technologies.



As we look forward to our third year, we continue to be committed to addressing the research needs and projected research progress that we originally proposed. Therefore, we have implemented an external review of all year 3 proposals. Each proposal will be reviewed by at least one external DOT/consulting engineer and one external researcher in the proposed subject area, and every effort will be made to avoid the conflict

of interest during the review process. Following the review, funding recommendations will be made during an executive meeting with our directors and advisory committee members.

This issue focuses on the data analytics research conducted by INSPIRE, specifically three projects, which aim to 1) develop new data collection strategies for improved probability of damage detection mechanisms, and develop algorithms for the derivation of bridge ratings from identified damage and visual inspection findings, 2) develop and validate a new framework of using the collected data to identify structure repair needs, and improve the resilience of the transportation system to disasters by enabling more effective resource distribution for more rapid recovery after a disaster, and 3) create a framework of training engineers and policy makers on robotic operation and image analysis for the inspection and preservation of transportation infrastructure.

This issue also highlights the work of the graduate and undergraduate students as well as post doctors engaged in our research. Students are our potential future transportation workforce. They are the torch bearers of advanced technologies into practical applications.

We invite you to read the featured articles and news of the INSPIRE UTC, and visit our website at [inspire-utc.mst.edu](http://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. Abnett Distinguished Chair in Civil Engineering  
Director, INSPIRE University Transportation Center  
Missouri University of Science and Technology

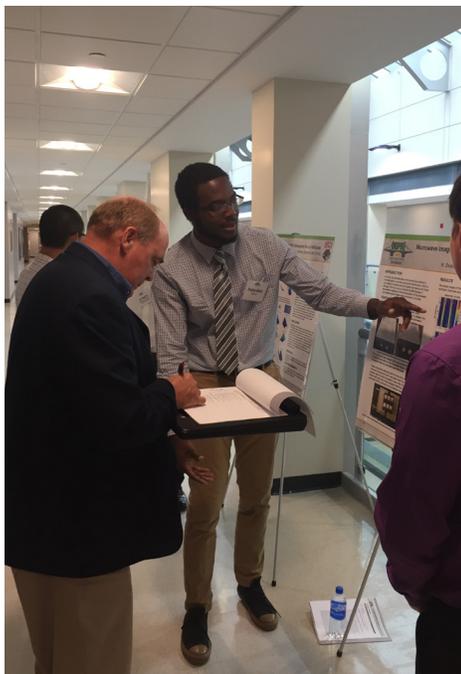


## INSPIRE UTC holds first annual meeting

The INSPIRE UTC held its 2018 Annual Meeting on the Missouri S&T campus August 14-15, 2018. Participants included INSPIRE UTC consortium members, external advisory committee members, graduate students working on INSPIRE research projects and special invited guests.

Activities were open to campus students and faculty, and included technical research presentations by INSPIRE faculty, an executive meeting and panel discussion with the advisory committee, a graduate student poster session and awards ceremony, and a pedestrian bridge test demonstration.

View the technical program at:  
[inspire-utc.mst.edu/annualmeeting](http://inspire-utc.mst.edu/annualmeeting)



## VICE PROVOST'S MESSAGE



In my first couple of weeks at Missouri S&T, I had the pleasure of learning about most Centers, including the University Transportation Center (UTC) and the INSPIRE consortium. INSPIRE's goal of inspecting the nation's infrastructure is a bold vision that may someday transform the infrastructure through exciting research happening right here at S&T. I am impressed by the drones, the climbing robots, and the sensors developed at the Center. But most of all I am impressed by the collaborative activities of our faculty, the inclusion of graduate and undergraduate students in the research, and the outreach through the advisory committee, webinars, FIRST robotics competition, publications, books, conferences, NSBE pre-college initiative, and summer camps. I look forward to continuing successes and contributions of UTC and INSPIRE which make all of S&T proud.

### Costas Tsatsoulis

Vice Chancellor of Research and  
Dean of Graduate Studies

## 2018 graduate student poster session winners

INSPIRE graduate students from all consortium institutions attended the annual meeting. Participating students interacted with transportation professionals from government and industry sectors. A graduate student poster session was held to offer 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.

The INSPIRE UTC External Advisory Committee members who attended the annual meeting served as judges for the poster competition. First, second and third place awards were presented to the following students:



### 1ST PLACE

**Chuanrui Guo, Missouri S&T**

Integrated Fiber Optic Sensors for Strain, Temperature and Corrosion-induced Mass Loss Measurement



### 2ND PLACE

**Dan Li, Georgia Institute of Technology**

Thermally-Stable Passive Antenna Sensor for Strain and Crack Monitoring



### 3RD PLACE

**Liang Yang, The City College of New York**

Deep Semantic 3D Visual Metric Reconstruction Using Wall-climbing Robot

## IN THE NEWS



**Dr. Anil Agrawal**, Herbert G. Kayser Professor of Structural/Bridge Engineering at The City College of New York, and associate director of the INSPIRE UTC, was interviewed by CNN International on the Morandi Bridge collapse that occurred in Genoa, Italy on August 14, 2018.

Read the full interview at: [cnn.it/2PlwLu0](http://cnn.it/2PlwLu0)

**Dr. Reza Zoughi**, Schlumberger Distinguished Professor of electrical and computer engineering at Missouri S&T, and INSPIRE UTC principal investigator, was interviewed by KOLR 10 News on September 16, 2018 on the 3-D microwave video camera technology he and his research team are developing.



This technology has many applications. One potential application may be using this imaging technique for bridge inspection and evaluation.

Watch the full interview at: [bit.ly/2PiVWh1](http://bit.ly/2PiVWh1)

[inspire-utc.mst.edu/news](http://inspire-utc.mst.edu/news)

## Missouri S&T Scholar's Mine receives CoreTrustSeal certification

In June 2018, Scholar's Mine, Missouri S&T's on-line repository of research papers, creative works and other documents, received CoreTrustSeal certification which signifies that Scholars' Mine is a trusted and certified repository for research data.

View the certification at: [bit.ly/2RLQXSC](http://bit.ly/2RLQXSC)



## Institutional pairing for summer research

### MEET STACEY CUBOS FROM UNLV

A summer research exchange program was implemented by INSPIRE consortium members, the University of Nevada, Las Vegas (UNLV), and the University of Nevada, Reno (UNR).

Stacey Cubos, a junior in the electrical engineering program at UNLV, was deployed to UNR for a 10-week summer research experience from June – August 2018. At UNR, Stacey worked with Dr. Hung La, INSPIRE principal investigator and director of the UNR Advanced Robotics and Automation (ARA) Laboratory on the project, *Eddy Current Flaw Detector Inspection Robot Simulation in Virtual Reality*. This project aims to prevent the percent of human casualties in manual bridge inspections through the use of virtual reality system simulation. The project was part of UNR's Research Experience for Undergraduates (REU) program, which focuses on collaborative human-robot interaction.

Stacey is a 2015 graduate from Carson Senior High School in Carson, California. Stacey anticipates receiving a B.S. in electrical engineering from UNLV in May 2020.



For more information, visit:  
[inspire-utc.mst.edu/studentprograms](https://inspire-utc.mst.edu/studentprograms)

UNLV



## INSPIRE attends CUTC 2018 summer meeting

### MINNEAPOLIS, MINNESOTA

In June 2018, Dr. Genda Chen, INSPIRE UTC Director, and Amy Gillman, INSPIRE UTC Program Coordinator, attended the Council of University Transportation Centers (CUTC) Summer Meeting, hosted by the Center for Transportation Studies on the University of Minnesota campus in Minneapolis, MN.

For more information, visit:  
[cutc2018.umn.edu](https://cutc2018.umn.edu)



Photo: [cutc2018.umn.edu](https://cutc2018.umn.edu)



## INSPIRE implements nondestructive evaluation testing on campus

The INSPIRE UTC conducts research to develop safer, faster, more efficient, and more cost-effective methods for bridge inspection and maintenance. S&T faculty from civil and electrical engineering, engineering management, and computer science are collaborating to develop these new methods which include the use of nondestructive evaluation devices and remotely-controlled robotic platforms.

With the permission and cooperation of Missouri S&T Facilities Operations, INSPIRE is conducting research testing on the pedestrian bridge connected to the Computer Science Building on the Missouri S&T campus. The technologies that will be employed in the testing include microwave imaging, ground penetrating radar and impact-echo tests, hyperspectral, and thermal imaging.

1. In addition to locating rebars, deck delamination and other potential anomalies, high-resolution microwave imaging based on synthetic aperture radar (SAR) approach can potentially show the steel rebar corrosion.
2. Ground penetrating radar sends electromagnetic radiation waves and detects the reflected signals from subsurface structures, thus detecting rebar in the bridge deck and determining the thickness of the deck.
3. Impact-echo sends impact-generated sound waves that propagate through concrete and are reflected by internal flaws and external surfaces. It can be used to determine the location and extent of flaws such as cracks, debonding, delamination, and voids in the bridge deck and column.
4. Hyperspectral imaging obtains an array of electromagnetic spectra on the surface of the bridge deck for corrosion detection. The characteristic wavelength at absorption peak of each spectrum can be used as a spectral signature for certain chemicals generated during corrosion process.
5. Thermal infrared imaging measures the radiant temperature of the concrete deck and column of the bridge, and shows hot spots at subsurface delamination and anomalies as they interrupt the heat transfer through concrete.

The centralized location of the pedestrian bridge to the INSPIRE UTC serves ideally for this project, allowing research to be performed any time that weather permits, saving valuable time and maximizing funds. Usually, bridge testing such as this would require obtaining permission and access through the Department of Transportation to use an existing bridge structure most often many miles away. Besides its ideal location to the INSPIRE center, the pedestrian bridge also creates a much safer working environment as the work can be conducted without the added concern of oncoming traffic, distracted drivers and other unforeseen or unexpected safety issues.



# DEFECT DETECTION OF CONCRETE STRUCTURES THROUGH SOUNDING DATA ANALYTICS

Impact sounding has been recognized as an effective technique to detect delamination in concrete structures, such as concrete decks. The main challenge in implementing this technology into autonomous inspection systems is the development of advanced data analysis approach that can be used to identify defects reliably based on an analysis of sounding signals. In this study, three different approaches have been investigated to interpret sounding data. These three approaches are: power-spectral density (PSD) analysis, principal component analysis (PCA) and empirical mode decomposition (EMD) method. It has been observed that the defects in the concrete slab can be detected reliably using these data analysis algorithms, which can be implemented in robotic platforms, such as unmanned aerial vehicles (UAVs) and crawlers, for generating reliable inspection ratings of concrete structures.

Fig. 1 shows the setup of sounding excitation and data acquisition systems. Three different sounding sources have been tested to excite the surface of a structure, such as the bridge deck. In this case, the concrete slab is a strong floor slab with 1½ inch holes at 12 inch intervals along the width and length of the floor. These holes have been filled with foam to create the presence of delamination or damaged concrete. The three sounding tools used are: a traditional hammer, a vibration speaker, and a robotic crawler. For the data acquisition, a common vocal microphone together with a USB-port sound card connected to a laptop enabled the recording of the signal during the test.

The acquired sounding data can be shown or analyzed in either time domain or frequency domain. Fig. 2 shows two examples of the data generated by impacting the concrete floor with a hammer at both solid and defective (holes with foam) locations. In the time domain, the sounding data is represented in a waveform. In the frequency domain, however, the PSD shows the contributions of energy from different frequency bands. In Fig. 2, it is observed that the hammer's ringing is located around 6 kHz, while the slab's vibration lies in the range of 0-5 kHz. Under the impact excitation, the damaged location of the slab generates more energy in the low-frequency range than the solid location of the slab, as shown in Fig. 2. Thus, the distribution of the PSD curve can serve as a good indicator of defects in concrete slabs.

The dimension (number of data points in a dataset) of these PSD features is usually large and is difficult to be visualized for a large dataset. In this project, PCA has been performed to extract the first and second principal components from the PSD vectors. Fig. 3 shows the clustering of hammer sounding cases at the base of the first two principal components. It is clear that the defect cases and solid cases are well separated and the defects can be clearly classified using simple machine learning algorithms, such as support vector machine (SVM).

Besides mechanical impact, electric chirp sounding emitted by

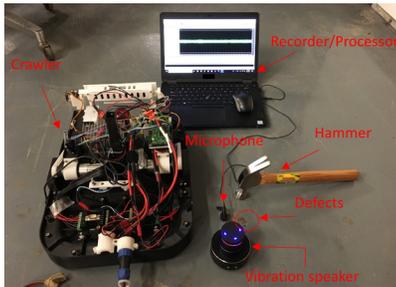
a vibration speaker shown in Fig. 1 was also used to excite the slab. The chirp signal was designed with its frequency increasing with time, covering 0~10 kHz frequency band of the slab. Fig. 4 shows the time history of the chirp sounding and the clustering results. It can be seen from Fig. 4(b) that the defect cases were well separated from the solid cases, which demonstrates that the impact hammer can be replaced by an electronic sounding source, such as a vibration speaker. The results in Fig. 4(b) also show the robustness of the data analysis approach. Also, it should be noted that using chirp sounding is much less labor-intensive than the mechanical impact process, which could be integrated into robotic platforms, like an UAV, to perform inspections.

**"It has been observed that the defects in the concrete slab can be detected reliably using these data analysis algorithms, which can be implemented in robotic platforms, such as unmanned aerial vehicles (UAVs) and crawlers, for generating reliable inspection ratings of concrete structures."**

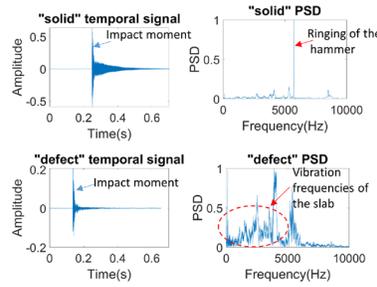
Fig. 1 also shows the wall climbing crawler that can be used as a sounding source. The crawler makes a significant amount of noise, which could be used as a sounding source for detection of delamination. During our preliminary investigation using the crawler, we did detect change in frequency content of sound signal captured near the damaged area. However, further work is needed in determining the feasibility of this approach.

In this study, EMD was used to remove the traffic noise from the sounding signals. EMD is an adaptive data analysis tool that is commonly used to break down any complicated signal set into several components, which usually pertain to different vibration modes and different physical meanings. Fig. 5 shows the decomposition of a noisy signal using the EMD method. It can be seen that the impact sounding signal was well separated from the noisy signals, which can be further processed by PSD and PCA. We are investigating the feasibility of analyzing the sounding signal from crawler for the detection of delamination.

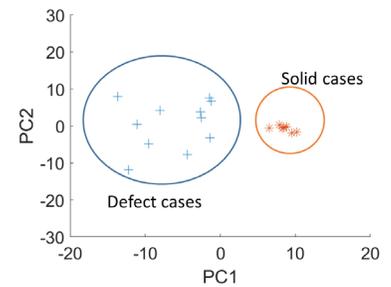
After extracting sounding signals using the EMD method, Hilbert-Huang transform was used to capture the instantaneous energy contributed from different frequency bands of the signal.



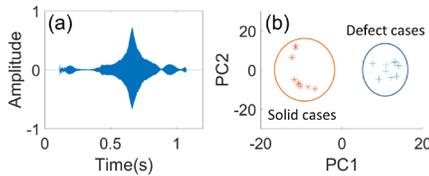
**Fig. 1. Setup of impact sounding of a concrete slab.**



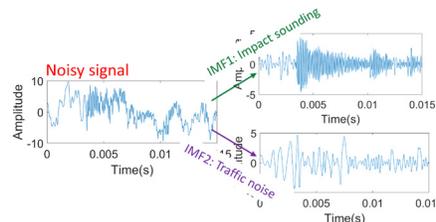
**Fig. 2. Sounding data in the time/frequency domain.**



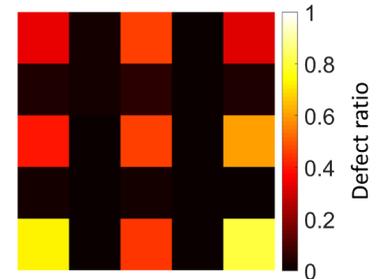
**Fig. 3. Clustering of the first two principal components of hammer sounding data.**



**Fig. 4. Results from chirp sounding excitation: (a) time history of chirp signals; (b) clustering results.**



**Fig. 5. Noise reduction by EMD.**



**Fig. 6. Contour of defect ratio of the concrete slab.**

Since defective areas were observed to vibrate more in the low-frequency band, a defect ratio was defined as the energy from a band of 0 to 2.5 kHz (low) divided by the energy from the whole frequency range of the signal. A contour of the defect ratio from the concrete slab using chirp sounding is shown in Fig. 6, where the embedded defects were all well detected and highlighted in a scale of severity of the defects, where 0 represents no damage and 1 represents severe damage. In this plot, areas covered in black are solid and those in lighter color from light red

to yellow are damaged locations. Here, regions marked in yellow are holes filled with lighter material, such as foam, whereas other regions marked by lighter red or other colors (except for black) represent holes filled with more solid type materials. The damage contour is deemed very useful for fast bridge deck inspections and decision making. We are constructing a 6 x 12 feet slab in the laboratory that will be engineered with different types of defects. This slab will be used in future research to capture sounding data on the slab to further verify and develop the approach.

**ABOUT THIS PROJECT**

Led by Dr. Anil K. Agrawal, Herbert G. Kayser Professor of Structural / Bridge Engineering at The City College of New York, the Quantitative Bridge Inspection Ratings using Autonomous Robotic Systems project is part of the INSPIRE UTC research program.



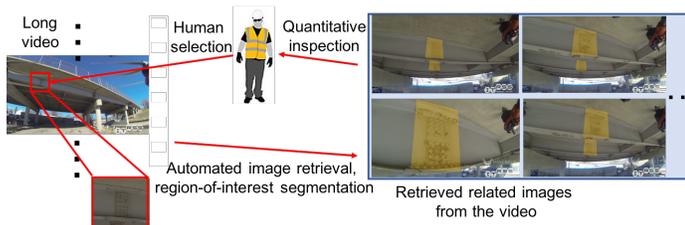
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## IMAGE DATA ANALYTICS TO SUPPORT ENGINEERS' DECISION-MAKING

Manual identification of abnormal features from long video is time-consuming. Machine learning can help engineers acquire mission critical data more efficiently. Currently, big data from bridge inspections can be collected from videos recorded with cameras mounted on drones. With a frame rate of 30 frames per second, 108,000 frames can be recorded in one hour.

This project aims to deploy image analysis methodologies to provide decision-making support for bridge inspection through long videos. Fig. 1 illustrates the main steps of an automatic retrieval of the region of interest from a long video. An inspector first selects some regions of interest (e.g. joints, beam, surface) in a frame. The image retrieval algorithm developed in this project then finds all related frames in the video. Finally, the collected set of images with localized regions of interest can be evaluated automatically by computer algorithms or verified by inspectors.

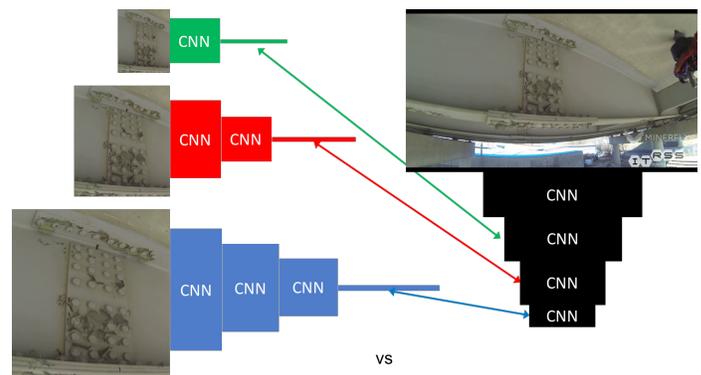


**Fig. 1. Automatic retrieval of the region of interest based on the initial input by inspectors.**

The main challenges of this project include: (1) within a video captured by a camera mounted on a drone, the viewpoint is changing, (2) the camera vibration introduced by the drone movement will affect the image quality, (3) the regions of interest have different scales in the videos, and (4) the regions to be inspected by bridge engineers may have different visual appearance or types.

A simple template matching by comparing the similarity between hand-crafted features of the query image and reference images may not overcome the previous challenges. Neural networks were used in the 1950s to solve the supervised learning problem. At the end of the 20<sup>th</sup> century, neural networks were applied to the handwriting digital recognition task and achieved superior performance. However, the neural network method relies on big training data, efficient optimization methods and powerful computation resources. In 2012, deep neural networks were proposed to solve the large scale image classification problem. Since then, deep neural networks remained the hottest machine learning topic in many industry applications.

In this project, a multi-scale Siamese neural network and one-shot learning algorithm are proposed to solve the region of interest detection problem. Two steps are taken: (1) multi-scale convolutional neural network for feature extracting and matching, and (2) Siamese neural network for localizing the region of interest.



**Fig. 2. The multi-scale convolutional neural network for feature extraction and matching.**

In the multi-scale convolutional neural network, the target region of interest is first manually selected by inspectors in a few frames of the video. Then, the selected object region (image patch) is up-sampled or down-sampled to several scales. Those patches at different scales are fed into a convolutional neural network (CNN). The smaller patch will generate the feature vector at the lower level of the CNN. The larger patch will get the feature vector at the higher level of the CNN. The test image will also be given to the CNN and generate the feature map at each level of the CNN. Each feature map is a 3D matrix. The physical meaning of the feature map is that at each location it has one feature vector. The feature vectors of the target object patch are compared with the feature vectors of the test image at corresponding levels of CNN, which generates a 2D probability map that tells us how likely the object is detected at specific locations in the test image.

The Siamese neural network is an advanced algorithm for image matching. Instead of using different neural networks for comparing two images (target object patch and test image in our case), the Siamese neural network can share some network architectures. Our proposed multi-scale Siamese neural network is showed in Fig. 3.

"Manual identification of abnormal features from long video is time-consuming. Machine learning can help engineers acquire mission critical data more efficiently."

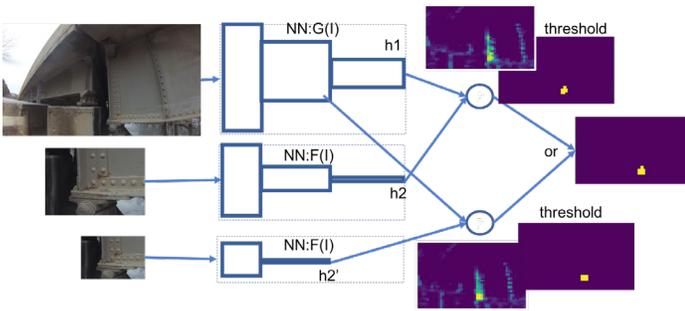


Fig. 3. The proposed multi-scale Siamese neural network.

The features from the test image are extracted by neural network G, and then compared with the feature vectors extracted by neural network F from the target patch. The difference of the two feature vectors is measured to generate a probability map which can be thresholded as a bitmap. Similarly, neural network F can be applied to the target patch at different scales and extract features to compare with the test image. Finally, the detections at different scales can be fused together. The entire neural network, including the two shared network architectures, can be trained in an end-to-end manner.

Fig. 4 shows the raw images and detected regions of interest. The bitmap (hard prediction) is thresholded from the probability map (soft prediction). The hard predictions from different scales are fused to localize the region of interest in the test image.

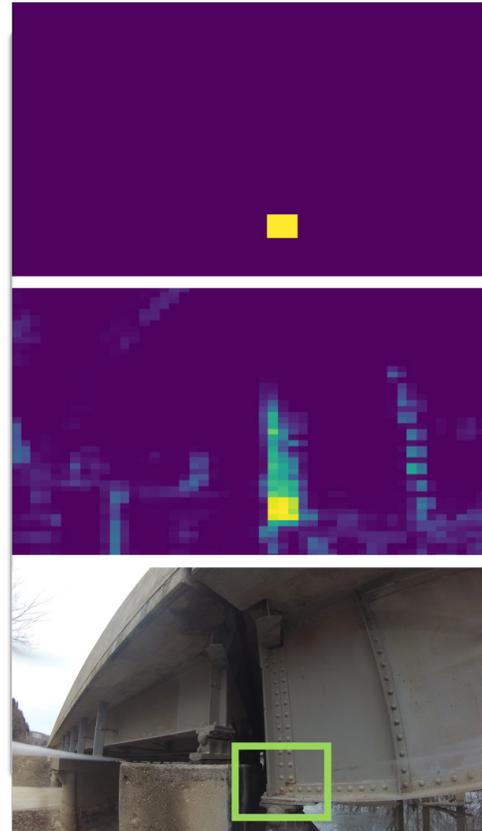


Fig. 4. Hard prediction, soft prediction and detected bounding box on the test image.

### ABOUT THIS PROJECT

This article was prepared by Tianyi Zhao, Zhaozheng Yin, and Ruwen Qin. Led by Dr. Ruwen Qin in Engineering Management and Systems Engineering at Missouri University of Science and Technology, the project, *A Training Framework of Robotic Operation and Imaging Analysis for Decision-Making in Bridge Inspection and Preservation*, is part of the INSPIRE UTC research program. For more information on this project, please contact Dr. Ruwen Qin at [qinr@mst.edu](mailto:qinr@mst.edu) or (573) 341-4493.



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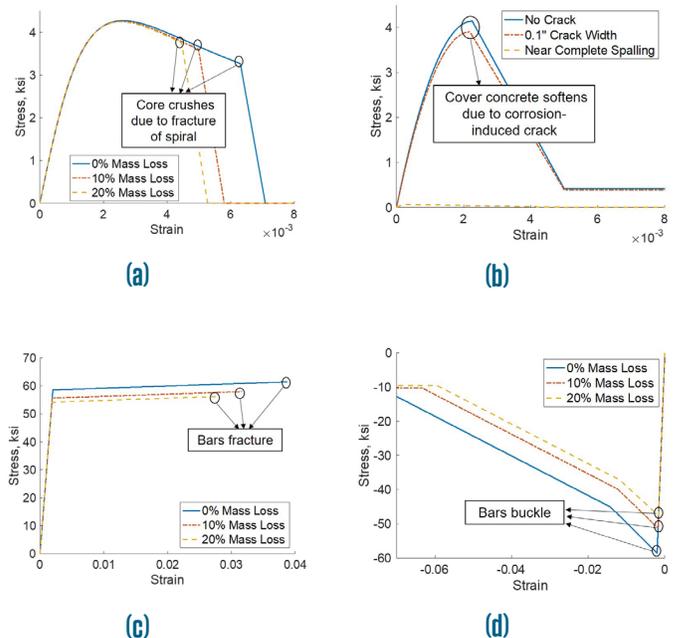
## TURNING DATA INTO DECISIONS THROUGH BRIDGE MODEL UPDATING



As data becomes increasingly prevalent, it is critical to incorporate this data into the assessment and prediction of bridges being monitored. This incorporation is completed by creating bridge models and updating the models with inspection data. The updated models can then be used to predict the performance of bridges in varying conditions, facilitating prioritization of bridges in maintenance, repair, and retrofit decisions.

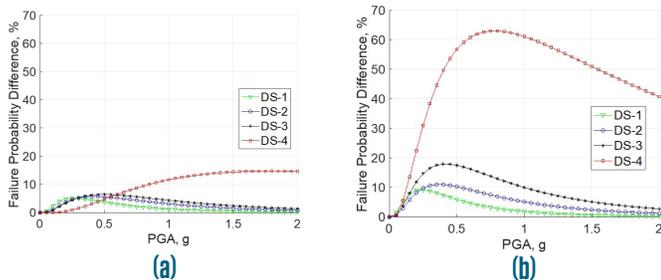
As an example, corrosion-induced mass losses of transverse and longitudinal reinforcement in reinforced concrete columns are considered. The impacts of corrosion on the predicted bridge performance are investigated both analytically and computationally. Flexure-critical columns have relatively ductile failure modes that result from buckling of longitudinal bars and fracture of transverse reinforcement. Corroded flexure-critical columns, however, no longer behave in such a manner and their behavior can be difficult to predict.

Fig. 1 shows the stress-strain curves of reinforced concrete columns with various degrees of rebar corrosion and associated cracking, resulting in different failure modes. For example, premature fracture of transverse reinforcement due to corrosion can lead to crushing of the core concrete.



**Fig. 1. Effect of corrosion and cracking for (a) core concrete, (b) cover concrete, (c) steel in tension and (d) steel in compression with bar buckling.**

When a bridge with flexure-critical columns experiences varying degrees of corrosion, the probabilities of the bridge exceeding undesired damage states under varying loading intensities can be calculated. Four damage states (DS) considered range from slight damage (DS-1) to complete damage (DS-4) nearing collapse. Fig. 2 shows the differences in failure probabilities of exceeding each of the damage states compared to the pristine state when 10% and 20% mass losses are considered. The loading intensity is measured as a function of peak ground acceleration (PGA).



**Fig. 2. Differences in failure probability between the pristine state and (a) 10% mass loss and (b) 20% mass loss corrosion levels for four damage states.**

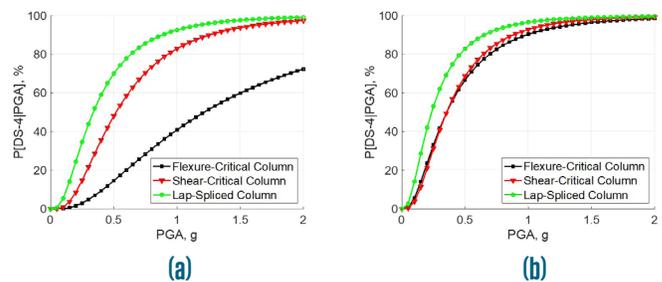
It can be observed from Fig. 2 that corrosion is of less concern at low damage states, but becomes increasingly significant as the corrosion level increases. For the most severe damage state, 20% loss of mass increases the probabilities of exceeding that damage state by as much as 60%.

In contrast to flexure-critical bridges, bridges vulnerable to shear failure and pull-out failure of columns due to lap splice failures are often brittle and catastrophic, making it important to be able to conduct analyses to better understand and predict their behavior. In shear-critical columns, corrosion leads to a reduction of the shear strength limit. In lap-spliced columns, corrosion reduces the steel reinforcement section, reduces ductility, and more importantly, affects the bond between the concrete

and reinforcement. At the lap splice, deterioration of the bond becomes critical, leading to bond failure. Volumetric expansion of reinforcement due to corrosion imposes tensile stress on the surrounding concrete. Micro-cracks form once the stress exceeds the tensile stress of concrete. Splitting of concrete cover due to corrosion-induced cracking leads to bond deterioration as well as loss of the force transferring mechanism between the concrete and steel.

**"As data becomes increasingly prevalent, it is critical to incorporate this data into the assessment and prediction of bridges being monitored."**

Fig. 3 compares the effects of corrosion on bridges with columns subject to the three potential failure modes. The probability of exceeding the most severe damage state (DS-4) as a function of increasing loading intensity as measured by PGA are shown. The lap-spliced columns are the most vulnerable for bridges with 10% mass loss of reinforcement, followed by shear-critical then flexure-critical columns.



**Fig. 3. Probability of exceeding most severe damage state considering varying failure modes for corrosion levels of (a) 10% mass loss and (b) 20% mass loss.**

## ABOUT THIS PROJECT

Led by Dr. Iris Tien in the School of Civil and Environmental Engineering at the Georgia Institute of Technology, the Bridge Resilience Assessment with INSPIRE Data project is part of the INSPIRE UTC research program.



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## Missouri S&T MinerFly team

Behind a nondescript door at Missouri S&T, a small team works to provide an unusual capability to the research community - a complete flight service for airborne sensors. This is the MinerFly team, whose purpose is to remove the burden of flight operations from research engineers and scientists. From tiny multi-rotor drones, to large fixed wing unmanned craft to even larger manned aircraft, the MinerFly team provides design services, aircraft, pilots, Federal Aviation Administration coordination for safety and legality, and expertise to support data collection.

Alec Reven, an S&T graduate in Computer Engineering, is the lead Unmanned Aerial Systems (UAS) pilot and primary student manager. "We design, build, fly - whatever our research faculty need," he said. "MinerFly is a part of a larger team of technology-focused research support groups. We want all our services to provide competitive advantage for our researchers".

The MinerFly group employs 2 to 10 students at any given time. "Student workers are critical to our success - we give them real-world experience, and they give us hard work and developing ideas," Alec continued. "Their work experience tends to be pretty limited when they start with us, but we give them projects and mentoring to ensure their success, if they put in the wrench time." This experience gained from MinerFly projects can give students a valuable asset upon graduation in the form of real-world skills.

Because MinerFly builds and maintains its own unmanned aerial systems, it needs a wide range of skill sets to succeed. Andrew Gerth, a student worker at MinerFly, adds that since MinerFly encompasses a wide range of engineering students, it has allowed him to collaborate with people outside his degree and gain valuable new skills from them, further enhancing his understanding of unmanned aerial systems. "Going to work every day promises a new and exciting set of challenges that need to be solved in order to keep our capabilities up to date for researchers." Thanks to this group collaboration across disciplines, MinerFly is able to keep its unmanned aerial systems running effectively.

How are these unmanned aerial systems useful for researchers? Drones and their counterparts can safely travel to areas where humans cannot easily. They can safely and relatively inexpensively measure floodwaters, examine infrastructure, and survey rough terrain. One of the early MinerFly collaborations was with the INSPIRE center. The MinerFly team integrated a magnetometer on an existing aircraft for gathering magnetic rock location data for evaluating how riverbeds change during floods. Other work includes outreach efforts, showcasing UAS capabilities to high school students and manned aircraft pilots through a variety of demonstrations and display activities.

MinerFly provides a unique service to the regional research community, enabling aerial data collection to be performed easily, safely, and legally, while utilizing talent and skills of S&T students.



Article by Mark Bookout, Director, Information Technology Research Support Services, Missouri S&T

..... For more information, visit: [itrss.mst.edu/minerfly](http://itrss.mst.edu/minerfly) .....



# Rolla High School senior develops sensing programs for UAVs

## MEET PRANAL MADRIA FROM MISSOURI S&T

Pranal Madria, a senior at Rolla High School in Rolla, Missouri, came to Missouri S&T as a dually enrolled student with a passion for computer science and robotics research. In the summer of 2018, the INSPIRE University Transportation Center hired Madria to assist MinerFly research services with designing a software program to sense obstacles using computer vision on a mobile platform. “The idea was that we could use this technology to implement sense and avoid protocols on our UAV’s”, says Alec Reven, Systems Administrator for IT Research Support Services and certified MinerFly UAV pilot. “When he began helping, the program couldn’t do much more than connect to a couple web cams; after he left it was picking up specific objects and determining how far away they were from the cameras. He may not have started the project from scratch, but he took it to the next level of sophistication and usability.”

Madria is grateful for his summer learning experience with MinerFly and the INSPIRE UTC.

“It was a fantastic experience where I was able to apply what I have learned from robotics at the high school and the computer science classes I have taken at Missouri S&T,” says Madria. “Through this unique experience, I learned not only about vision programming for UAVs, but also about all of the measures taken to mitigate the risks involved when using UAVs in a real world application.”



“Through this unique experience, I learned not only about vision programming for UAVs, but also about all of the measures taken to mitigate the risks involved when using UAVs in a real world application.”

- PRANAL MADRIA

## RECENT WEBINAR



### TOWARD AUTONOMOUS WALL-CLIMBING ROBOTS FOR INSPECTION OF CONCRETE BRIDGES AND TUNNELS

**Presented:** September 19, 2018

**Speaker:** Dr. Jizhong Xiao  
Professor  
Electrical Engineering Department  
The City College of New York

**Online:** [scholarsmine.mst.edu/inspire\\_webinars](http://scholarsmine.mst.edu/inspire_webinars)  
[inspire-utc.mst.edu/webinars](http://inspire-utc.mst.edu/webinars)

## WEBINAR ARCHIVES

2018	<b>Toward Autonomous Wall-climbing Robots for Inspection of Concrete Bridges and Tunnels</b> By Dr. Jizhong Xiao, The City College of New York
	<b>Climbing Robots for Steel Bridge Inspection and Evaluation</b> By Dr. Hung La, University of Nevada, Reno
	<b>Microwave Materials Characterization and Imaging for Structural Health Monitoring</b> By Dr. Reza Zoughi, Missouri S&T
2017	<b>Drone-Enabled Remote Sensing for Transportation Infrastructure Assessment</b> By Colin Brooks, Michigan Tech
	<b>Lab-On-Sensor for Structural Behavior Monitoring: Theory and Applications</b> By Dr. Genda Chen, Missouri S&T

VIEW PAST WEBINARS AT:

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## UPCOMING WEBINAR



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

**Presented:** December 10, 2018, 11:00 am (Central)

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

**Register:** [inspire-utc.mst.edu/webinars](http://inspire-utc.mst.edu/webinars)

Artificial Intelligence, particularly deep learning, has recently received increasing attention in many applications, such as image classification, speech recognition, and computer games. The success of deep learning algorithms requires big annotated datasets for training, gradient-based optimization algorithms, and powerful computational resources. In the case of civil infrastructure inspection, we can collect big data from different imaging sensors such as color, thermal, and hyperspectral cameras. Three issues encounter in this application. First, it is tedious and expensive to let human experts annotate the datasets to train deep learning algorithms. Second, the off-line trained deep learning algorithms may not be able to adapt to new civil infrastructures. Third and lastly, the trained deep learning algorithm works like a black box on new data, without the domain knowledge from human experts. In this project, we investigate intelligent data analytics algorithms with human experts in the loop, called Assistive Intelligence (AI). Using the bridge inspection as a case study, we aim to find regions-of-interest (e.g., joints with damages) over long video sequences. The data analytics algorithm is initially trained from a small set of data. Given the dataset of a new bridge, bridge experts only need to annotate a few region-of-interest examples as the seed; our algorithm will retrieve corresponding examples in the rest of videos. Human experts can also return some incorrectly retrieved samples to the data analytics algorithm for further refinement. Thus, while the data analytics algorithm can assist human in an efficient way, bridge experts can leverage their domain knowledge in the adaptation of the computational tool in different scenarios.



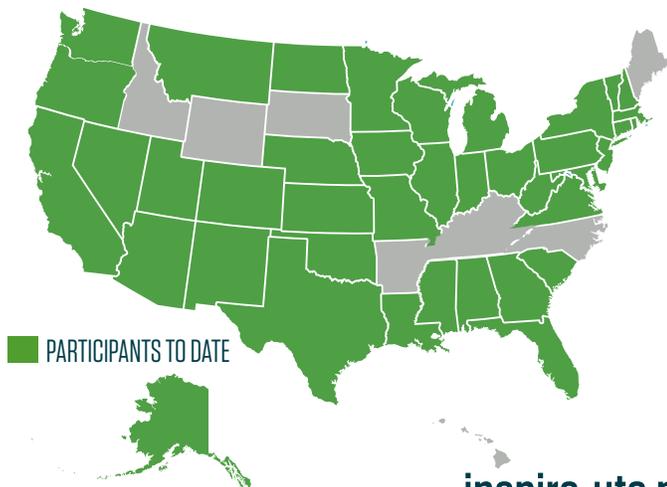
# INSPIRE WEBINARS

## TECHNOLOGY TRANSFER

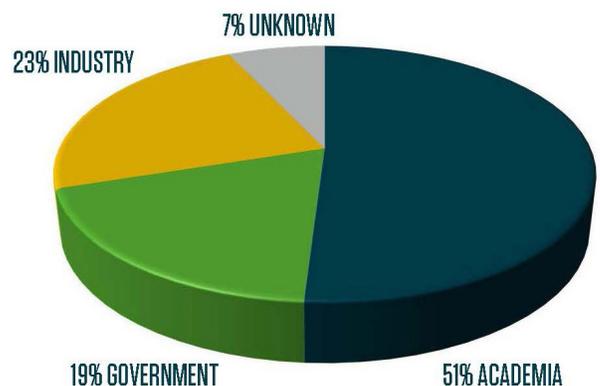
AIMED AT INFRASTRUCTURE INSPECTION AND PRESERVATION SOLUTIONS



US PARTICIPATION



SECTOR PARTICIPATION



[inspire-utc.mst.edu/webinars](http://inspire-utc.mst.edu/webinars)

## Local robotics team visits UNLV's Drones and Autonomous Systems Lab

On April 11, 2018, Dr. Paul Oh of UNLV hosted 15 students from the Robert O. Gibson Middle School robotics team for a visit to the Drones and Autonomous Systems Lab (DASL). Dongbin Kim, DASL Manager and mechanical engineering Ph.D. student at UNLV, directed the students through various robotics demonstrations highlighting the work of the laboratory.



Read the full article at: [bit.ly/2Dfm5TK](http://bit.ly/2Dfm5TK) | Watch the video at: <https://bit.ly/2QvA9yZ>

## UNR Advanced Robotics and Automation Lab Tours

On August 7, 2018, Dr. Hung La and his students at UNR organized two lab tours for robot and virtual reality demonstration at UNR's Advanced Robotics and Automation (ARA) Lab. Participants included 43 visitors of the Emissions Measurement and Testing Committee.

## UNR Research Experiences for Undergraduates Site Event

On June 1, 2018, Dr. Hung La and his students at UNR organized and hosted a lab tour and robotics demonstration for visitors of the NSF Research Experiences for Undergraduates (REU) Site event at UNR's ARA Lab. Participants included 30 students from 4 different states, including California, New Hampshire, Oklahoma and Nevada.

## Expanding Your Horizons Workshop

On October 5, 2018, the INSPIRE UTC and Mid America Transportation Center (MATC) co-hosted two hands-on transportation workshops during the Expanding Your Horizons (EYH) Conference on the Missouri S&T campus. EYH is an annual conference for 7th and 8th grade girls, designed to help participants better understand some of the many career choices they can explore in S.T.E.M. areas. This year, INSPIRE and MATC hosted Traffic Jam!, a hands-on workshop that engaged 32 Missouri students in transportation computer games where they learned how to design traffic signals and do city planning to reduce traffic congestions. The workshop was coordinated by the INSPIRE UTC and presented by Dr. Xianbiao Hu, assistant professor of civil, architectural & environmental engineering, and MATC principal investigator at Missouri S&T.



## 2018 MoDOT Transportation Camp

On July 17, 2018, the INSPIRE UTC hosted a one-day MoDOT Transportation Camp on the Missouri S&T campus as part of MoDOT's annual Youth Transportation Conference. Each summer, MoDOT selects 30 students from across the state to participate in the camp exposing them to numerous career opportunities in the field of transportation.

Attendees spent a full day visiting S&T and explored a variety of topics related to transportation. Following a welcome address by the center's associate director, Dr. Suzanna Long, and a presentation by the Admission's Office, students attended a series of activities organized by INSPIRE and MATC faculty members: Drs. Genda Chen, Xianbiao Hu, Grace Yan, and Hongyan Ma. The Missouri S&T MinerFly Team provided an unmanned aerial vehicle (UAV) demonstration at the Havener Center, students participated in transportation-related computer games, a bridge engineering competition, a tour of the System and Process Assessment Research (SPAR) Laboratory, and hands-on activities in the Wind Hazard Mitigation (WHAM) Laboratory, and Smart and Functional Construction Materials (SmarF) Lab.



# STUDENT PARTICIPATION

## MEET THE HARD-WORKING GRADUATE STUDENTS OF THE INSPIRE UTC

This last year, the INSPIRE consortium engaged a total of 19 graduate students in transportation research projects supported by grant, including 16 PhD students and 3 masters level students. INSPIRE graduate students from diverse disciplines have the opportunity to collaborate on innovative transportation research, which in turn will expand the research strength of the Center. Participating students also have the opportunity to engage with external advisory committee members. This connects them to the transportation industry and provides job opportunities within the transportation field. The students currently working on INSPIRE projects are highlighted below.



### ABDULLAH ALHAJ, MISSOURI S&T

**INSPIRE Project:** Hyperspectral Image Analysis for Mechanical and Chemical Properties of Concrete and Steel Surfaces, **Research Advisor:** Dr. Genda Chen

Abdullah Alhaj received a B.S. degree in applied geophysics in 2015 from King Saud University in Riyadh, Saudi Arabia, and completed a M.S. degree in geological engineering in June 2018 at Missouri S&T. In 2018, he enrolled in the Ph.D. program at S&T where he researches structural health monitoring for concrete and steel structures using non-destructive techniques. The deployment of these individual and/or integrated nondestructive techniques is aimed to monitor bridge deck condition in either local or global structural health monitoring systems. Abdullah's main role in Dr. Genda Chen's INSPIRE research project is to evaluate the capability of the up-to-date technology of hyperspectral imaging in structural damage detection by analyzing the changes in the mechanical and chemical properties of concrete and steel materials of bridge decks.



### RAN CAO, THE CITY COLLEGE OF NEW YORK

**INSPIRE Project:** Quantitative Bridge Inspection Ratings using Autonomous Robotic Systems, **Research Advisor:** Dr. Anil K. Agrawal

Ran Cao graduated with honors and received a B.S. in civil engineering in 2015 from Hunan University, Changsha, China. He then enrolled in the civil engineering doctoral program at The City College of New York. Ran's role in Dr. Anil Agrawal's INSPIRE research project focuses on data analysis of impact sounding data for delamination detection and development of impact sounding sources for UAV and crawler systems. A software tool will be developed for an automated rating system for concrete and steel members using robotic inspection data.



### LIANG FAN, MISSOURI S&T

**INSPIRE Projects:** 3D Microwave Camera for Concrete Delamination and Steel Corrosion Detection, and Hyperspectral Image Analysis for Mechanical and Chemical Properties of Concrete and Steel Surfaces, **Research Advisor:** Dr. Genda Chen

Liang Fan received a M.S. degree in civil engineering in 2014 from Southwest Jiaotong University, China. At Missouri S&T, he is currently working towards his Ph.D. degree at the System and Process Assessment Research (SPAR) Lab. His research interests include corrosion-resistant enamel coating and corrosion monitoring with distributed optic fiber sensor. Liang's role in Dr. Genda Chen's INSPIRE research projects is to access the concrete degradation and steel corrosion with hyperspectral imaging and to analyze corrosion of steel bars embedded in concrete with microwave imaging.



## CLAYTON FRITSCHÉ, MISSOURI S&T

**INSPIRE Project:** Preliminary Studies towards the Development of Bridge Inspection Robot Deployment Systems (BIRDS) in Year 3, **Research Advisor:** Dr. Genda Chen

Clayton Fritsche received a B.S. degree in civil engineering in 2017 from Missouri S&T. After completion, Clayton continued his education at Missouri S&T to complete a M.S. degree in civil engineering. His role in Dr. Genda Chen's INSPIRE research project is to assist in the design and application of an unmanned aerial and traversing system which may be used as a platform for bridge inspection devices. Ultimately, the drone may assist current inspection techniques as a tool for bridge inspectors. This would increase inspector safety and shorten or prevent lane closures, along with saving time and money by reducing inspection duration.



## CHUANRUI GUO, MISSOURI S&T

**INSPIRE Project:** In-line Long Period Grating and Brillouin Scattering Fiber Optic Sensors for Strain, Temperature, Chloride Concentration, and Steel Mass Loss Measurement in Bridge Applications, **Research Advisor:** Dr. Genda Chen

Chuanrui Guo received a B.S. degree and M.S. degree in civil engineering in 2010 and 2014 respectively from Central South University, Hunan, China. After that, he enrolled in the doctoral program at Missouri S&T where he focuses on structural health monitoring, laser-aided fiber grating, chemical and physical vapor deposition, fiber optic sensor and nano-material synthesis, manufacturing and applications. Chuanrui's role in Dr. Genda Chen's INSPIRE research project is to develop a long-term integrated in-line fiber optic sensor based on long period fiber grating and Graphene-AgNW film Fe-C electroplating to monitor strain, temperature and corrosion induced mass loss simultaneously in civil infrastructures such as steel bridges and steel members in concrete structures.



## BLAKE HAMENT, UNIVERSITY OF NEVADA, LAS VEGAS

**INSPIRE Project:** Mobile-manipulating UAVs for Sensor Installation, Bridge Inspection, and Maintenance, **Research Advisor:** Dr. Paul Oh

Blake Hament received a B.S. in physics from Duke University where he worked on high-energy particle physics research related to filtering data from the Large Hadron Collider. Blake is currently a Ph.D. student and research assistant at the University of Nevada, Las Vegas' Drones and Autonomous Systems Lab (DASL). Blake's role in Dr. Paul Oh's INSPIRE research project is 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 research, he has worked on several projects related to humanoid computer vision, uneven terrain path-planning, heterogenous robot collaboration, and virtual reality snowboard training.



## MUHAMMAD MONJURUL KARIM, MISSOURI S&T

**INSPIRE Project:** A Training Framework of Robotic Operation and Imaging Analysis for Decision-Making in Bridge Inspection and Preservation, **Research Advisor:** Dr. Ruwen Qin

Muhammad Monjurul Karim is a first-year Ph.D. student in engineering management and systems engineering at Missouri S&T. His research focuses on big data analysis of inspection images. He previously worked at several manufacturing companies and was involved with mathematical optimization in transportation, decision analysis and systems development. He obtained a B.S. in industrial and production engineering in 2014 from Bangladesh University of Engineering and Technology. Monjurul's role in Dr. Ruwen Qin's INSPIRE project is to implement a deep learning approach, which will semantically segment the meaningful bridge elements by reading the videos from a UAV or other remotely controlled robotic platform. The goal of his research is to eliminate the labor-intensive part of bridge inspections and automate the inspection process.

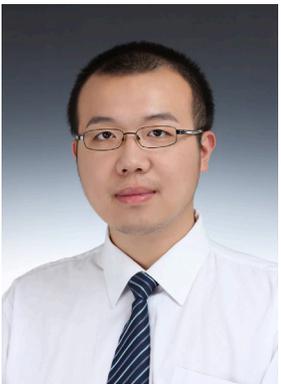
# STUDENT PARTICIPATION



## MATTHEW KLEGSETH, MISSOURI S&T

**INSPIRE Project:** In-line Long Period Grating and Brillouin Scattering Fiber Optic Sensors for Strain, Temperature, Chloride Concentration, and Steel Mass Loss Measurement in Bridge Applications, **Research Advisor:** Dr. Genda Chen

Matthew Klegseth received B.S. degrees in civil engineering and architectural engineering in 2016 from Missouri S&T. After completion of these degrees, he enrolled in the doctoral program at S&T where he researches structural health monitoring issues and fiber optic sensor technology. Matthew's role in Dr. Genda Chen's INSPIRE research project is to evaluate the role that the distributed fiber optic sensing system plays in the understanding of reinforced concrete structure behavior. Ultimately, the distributed fiber optic sensing system will be supplemented by grating-based sensors for monitoring of real-world bridges or large-scale bridge models. Matthew's future research interest is structural monitoring for damage due to fire using fiber optic sensors.



## DAN LI, GEORGIA INSTITUTE OF TECHNOLOGY

**INSPIRE Project:** Battery-free Antenna Sensors for Strain and Crack Monitoring of Bridge Structures, **Research Advisor:** Dr. Yang Wang

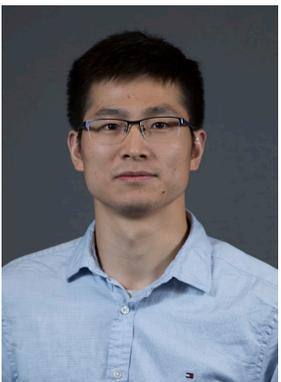
Dan Li received a B.S. in civil engineering in 2011 and a M.S. in civil engineering in 2014 from Tongji University, Shanghai, China. After completion of these degrees, he enrolled in the doctoral program at Georgia Tech where he is exploring structural health monitoring issues and passive patch antenna sensor technology. Dan's role in Dr. Yang Wang's INSPIRE research project is to design and evaluate a thermally stable passive patch antenna sensor for strain and crack monitoring of structures. The sensor is capable of detecting small strain and surface crack of structures while sustaining temperature disturbance.



## CHAO LIU, MISSOURI S&T

**INSPIRE Project:** 3D Microwave Camera for Concrete Delamination and Steel Corrosion Detection, **Research Advisor:** Dr. Reza Zoughi

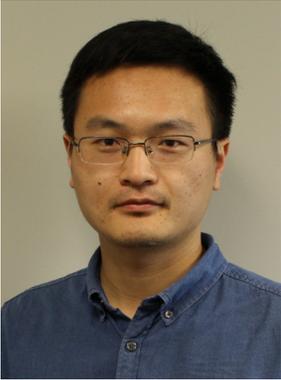
Chao Liu received a B.S. degree in electrical engineering in 2014 from Xidian University, Xi'an, China, and a M.S. degree in electromagnetic field and microwave technology in 2017 from Southeast University, Nanjing, Jiangsu, China. After completion of these degrees, he enrolled in the doctoral program at Missouri S&T where he researches structural health monitoring issues and microwave and millimeter-wave image technology. Chao's role in Dr. Reza Zoughi's INSPIRE research project is to evaluate the role that the 3D microwave camera system plays in the understanding of nondestructive detection of corroded rebar of reinforced concrete structure. Ultimately, the 3D microwave image system will be supplemented to help position the possible corruptions in real-world bridges. Chao's future research interest is the design of microwave and millimeter-wave image system for real-time structure health monitoring.



## ERIC (LIANG) YANG, THE CITY COLLEGE OF NEW YORK

**INSPIRE Project:** Quantitative Bridge Inspection Ratings using Autonomous Robotic Systems, **Research Advisor:** Dr. Jizhong Xiao

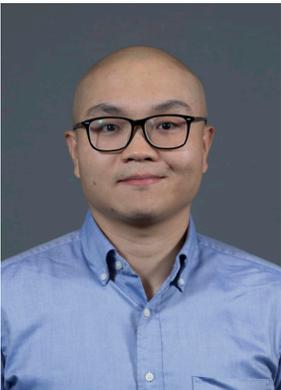
Eric (Liang) Yang received a B.S. in control technology and instrument in 2012 from Shenyang Aerospace University, Shenyang, China. After completion of his bachelor's degree, he enrolled in the Master-Ph.D. program at the Chinese Academy of Sciences and completed his master study mainly at the University of Science and Technology of China, where he researched UAV motion control. In 2016, he enrolled in the Ph.D. program in electrical engineering at The City College of New York where he researches infrastructure inspection in a visual and sounding approach using robots. Eric's role in Dr. Jizhong Xiao's INSPIRE research project is to research on automatic pixel-level segmentation and reconstruction using learning approach. Eric's future research interest is 3D spatial relation understanding and encoding with both static objects and moving human.



## XINZHE YUAN, MISSOURI S&T

**INSPIRE Project:** INSPIRE UTC Outreach and Education Activities, **Research Advisor:** Dr. Genda Chen

Xinzhe Yuan received a B.S. degree in civil engineering in 2012 from Zhejiang University, Hangzhou, China, and a M.S. degree in civil engineering in 2016 from Tongji University, Shanghai, China. He joined the Ph.D. program at Missouri S&T and works on a research project titled, A New SMART Shear Key for Earthquake and Multi-Hazards Mitigation. The focus of this project is to develop a new innovative device on bridges to mitigate the potential damage of bridges under earthquakes and hurricanes by preventing excessive movements of bridge girders. The ultimate goal of his research is to find a solution to save structures and lives from extreme disasters. Xinzhe is an active participant with the INSPIRE UTC and helps to raise public awareness by leading engineering outreach activities organized by the Center, including bridge engineering competitions for the MoDOT Transportation Camp and NSBE Pre-College Initiative outreach events at Missouri S&T.



## YIJIAN (ALBERT) ZHANG, GEORGIA INSTITUTE OF TECHNOLOGY

**INSPIRE Project:** Bridge Resilience Assessment with INSPIRE Data, **Research Advisor:** Dr. Iris Tien

Albert received a B.S. in civil and environmental engineering in 2012 and M.S. in 2014 from the University of California, Berkeley, California, USA. In 2016, he enrolled in the doctoral program at Georgia Tech where he focuses on a framework that uses the data collected from the robotic exploration of infrastructure to assess the condition of bridges and prioritize these structures for repair. Albert's role in Dr. Iris Tien's INSPIRE research project is to evaluate the effect of corrosion and scour on the structural response of bridges. Ultimately, the impact of corrosion and scour will be quantified in terms of failure probability in the framework of fragility assessment. Albert's future research interest includes structural reliability and nonlinear analysis of structure.



## TIANYI ZHAO, MISSOURI S&T

**INSPIRE Project:** A Training Framework of Robotic Operation and Imaging Analysis for Decision-Making in Bridge Inspection and Preservation, **Research Advisor:** Dr. Zhaozheng Yin

Tianyi Zhao received a B.S. in software engineering in 2015 from Xiamen University, Fujian, China, and a M.S. in computer science in 2017 from the University of North Carolina, Charlotte, North Carolina, USA. After completion of these degrees, she enrolled in the doctoral program at Missouri S&T where she researches image classification and microscopy image segmentation. Tianyi's role in Dr. Ruwen Qin's INSPIRE research project is to deploy image analysis methodologies to provide decision-making support for bridge inspection through long videos. Tianyi's future research interest is image analysis, including images classification, image segmentation and image matching.



## YANPING ZHU, MISSOURI S&T

**INSPIRE Project:** In-line Long Period Grating and Brillouin Scattering Fiber Optic Sensors for Strain, Temperature, Chloride Concentration, and Steel Mass Loss Measurement in Bridge Applications, **Research Advisor:** Dr. Genda Chen

Yanping Zhu received his M.S. in civil engineering in 2018 from Hunan University, China. After completion of his degrees, Yanping enrolled in the doctoral program at Missouri S&T where he researches structural health monitoring issues and fiber optic sensor technology. Yanping's role in Dr. Genda Chen's INSPIRE research project is to evaluate the effect of distributed fiber optic system deployment scheme in the understanding of ultra-high performance concrete structure behavior. Ultimately, the distributed fiber optic sensor will be integrated with grating-based sensors for monitoring of real-world bridges or large-scale bridge models. Yanping's future research interest is structural monitoring for deterioration due to aging using fiber optic sensors.

# STUDENT PARTICIPATION

## INSPIRE UNDERGRADUATE RESEARCH ASSISTANTS

Undergraduate students involved in research have the exciting opportunity to be directly involved with technology developments at the forefront of their chosen field of study. Last year, the INSPIRE consortium engaged a total of 22 undergraduate students in transportation research projects supported by the grant. Undergraduate research experiences help students prepare for graduate school and provide opportunities to work closely with faculty advisors. Some INSPIRE students participated in part-time or summer semester projects only, and others participated throughout the academic year. Following are a few of our outstanding student participants.



### STEPHON BARKER, MISSOURI S&T

**INSPIRE Project:** 3D Microwave Camera for Concrete Delamination and Steel Corrosion Detection, **Research Advisor:** Dr. Reza Zoughi

Stephon Barker is a senior in electrical engineering at Missouri S&T performing undergraduate research in Dr. Reza Zoughi's Applied Microwave Nondestructive Testing Laboratory. During the 2018 summer semester, his role in the INSPIRE research project was to continue with the progress made on detecting steel corrosion and concrete delamination through the use of microwave imaging. Stephon got the opportunity to conduct this nondestructive testing directly on the Missouri S&T computer science pedestrian bridge, which showed potential results of delamination and corrosion. Due to the size of the bridge, a new manual scanning was constructed to perform testing on each section of the bridge. Stephon plans to continue this research project to create a 3D microwave camera that will detect concrete delamination and steel corrosion detection.



### ASHLEY-ANN DAVIS, MISSOURI S&T

**INSPIRE Project:** Hyperspectral Image Analysis for Mechanical and Chemical Properties of Concrete and Steel Surfaces, **Research Advisor:** Dr. Genda Chen

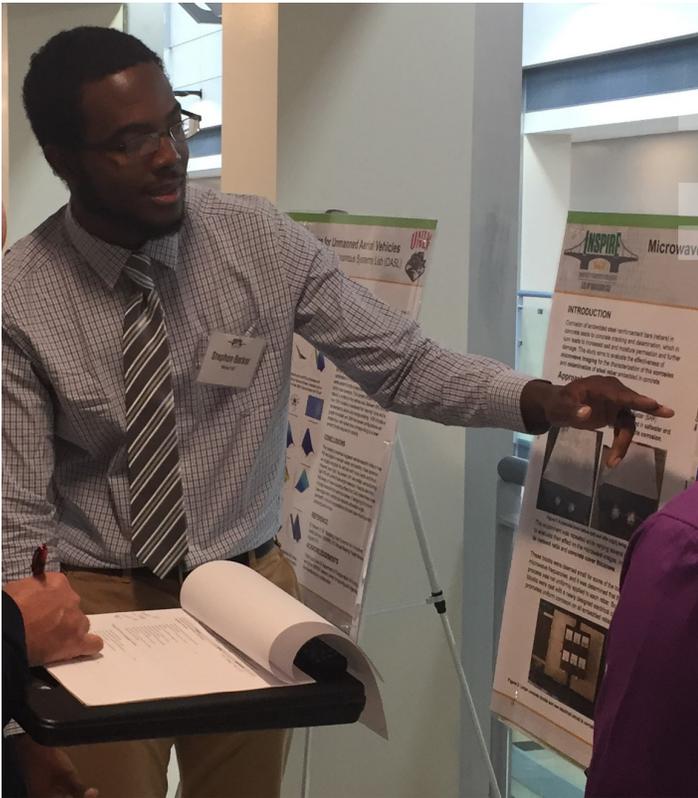
Ashley-Ann Davis is a sophomore at Missouri S&T, pursuing a double major in civil engineering and architectural engineering. Ashley is a 2018-2019 participant of the INSPIRE UTC Undergraduate Research Program. Her role in Dr. Genda Chen's INSPIRE research project is to help prepare concrete and steel test samples, characterize and categorize them, and prepare documentations for data curation in Scholars' Mine. Last summer, Ashley completed an internship at Clayco as a Project Engineer Intern. Ashley is the President of the student chapter of the National Society of Black Engineers, and is involved with Engineers Without Borders and works as a peer mentor.



### PRANAL MADRIA, MISSOURI S&T

**INSPIRE Projects:** MinerFly computer vision project, INSPIRE social media site development and communications, and INSPIRE video production projects, **Research Advisor:** Dr. Genda Chen

Pranal Madria is a senior at Rolla High School, in Rolla, Missouri who is dually enrolled as a student at Missouri S&T, studying computer science. In the summer of 2018, Pranal was hired as a research assistant for the INSPIRE UTC to assist the MinerFly team with a computer vision project. Pranal's role in the project was to design a software program to sense obstacles using computer vision on a mobile platform. Pranal also assists INSPIRE with social media site development and communications, and video production projects. After he graduates high school in 2019, Pranal plans to major in computer science and minor in statistics, wherever he attends college.



# UNDERGRADUATE RESEARCH

## SENIOR DESIGN TEAM, THE CITY COLLEGE OF NEW YORK

**INSPIRE Project:** Quantitative Bridge Inspection Ratings using Autonomous Robotic Systems

**Mentor:** Dr. Yong Chang,

**Research Advisor:** Dr. Jizhong Xiao

A senior design team at The City College of New York (CCNY), consisting of six mechanical engineering undergraduate students, assisted Dr. Jizhong Xiao with his INSPIRE research project. The project provided materials and supplies for the undergraduate students to research wall-climbing robot designs. Pictured right are the senior design students, along with their mentor, Dr. Yong Chang.



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# DOCTORAL PARTICIPATION

## POST DOCTORAL FELLOWS AND VISITING SCHOLARS

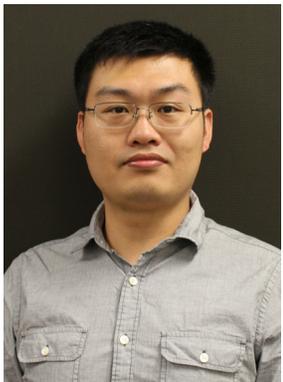
In the past 6 months, the INSPIRE UTC has involved 2 postdoctoral fellows and 3 visiting scholars in various Center activities and research work. During their transition period of professional development, they have made significant contributions to the success of the Center, becoming an integral part of the Center's operation. They have not only advanced research projects but also enriched the cultural environment surrounding the Center.



### DR. SIMING LIU, UNIVERSITY OF NEVADA, RENO

**INSPIRE Project:** Developing a Robotic Simulator and Video Games for Professional and Public Training, **Research Advisor:** Dr. Sushil Louis

Dr. Liu is a Lecturer in the department of computer science and engineering at the University of Nevada, Reno (UNR). He obtained his Ph.D. on artificial intelligence on RTS games from UNR in 2015. His research interests are broadly in the areas of search, optimization, machine learning, and computational intelligence, with a focus on applications on computer games and simulations. Dr. Liu's role in Dr. Sushil Louis's INSPIRE research project is to investigate and optimize the design of user interaction and user interfaces within a full 3D, game-like environment for training and control, investigate and optimize the tradeoff between manual and autonomous control of multi-robot teams for bridge inspection, train bridge inspectors in the use of the proposed multi-robot system, and provide human operators with complete situational awareness and operational control during an ongoing bridge inspection.



### DR. HONGYA QU, MISSOURI S&T

**INSPIRE Project:** INSPIRE UTC Outreach and Education Activities, **Research Advisor:** Dr. Genda Chen

Hongya Qu received his B.S. and M.S. degrees from Tongji University, China, in 2009, and 2012, respectively, and his Ph.D. degree in civil engineering from Missouri S&T in 2018. Presently, he is a post-doctoral fellow at the INSPIRE UTC. His research interests include signal processing, adaptive data analysis, structural dynamics, and non-destructive testing. Currently, Dr. Qu develops an adaptive wavelet transform and analysis framework with automatic search of optimal parameters in developed algorithms. These new algorithms have great potential to be applied to analyze imagery collected at the INSPIRE UTC.





## DR. HUAISHUAI SHANG, MISSOURI S&T

**Research Advisor:** Dr. Genda Chen

Dr. Huaishuai Shang is currently a visiting scholar in Dr. Genda Chen's INSPIRE research group at Missouri S&T. Dr. Shang received his M.S. degree in port, coastal and offshore engineering in 2006 from Dalian University of Technology, China. His master's research focused on reliability analysis of steel structures based on stability. He obtained his Ph.D. in structure engineering in 2007 from Dalian University of Technology. His doctoral research focused on experimental study on strength of plain concrete and air-entrained concrete under multiaxial loads after freeze-thaw cycles. Dr. Shang worked at the Shandong Academy of Building Research from 2007 to 2010, then joined Qingdao University of Technology in December of 2010. He is full Professor of Civil Engineering at Qingdao University of Technology and focuses on the research of behavior between steel bar and concrete after the coupling effect of long-term load and environment.



## DR. GANG WANG, MISSOURI S&T

**Research Advisor:** Dr. Genda Chen

Dr. Gang Wang is currently a visiting scholar in Dr. Genda Chen's INSPIRE research group at Missouri S&T. Dr. Wang received a B.S. in civil and hydraulic engineering in 2002 from Wuhan University of Hydraulic and Electric Engineering, China, and a M.S. and Ph.D. in hydraulic and hydroelectric engineering from Dalian University of Technology, China, in 2005 and 2008 respectively. His doctoral research focused on static and dynamic mechanical behavior of the joints of aging concrete structures, especially for concrete gravity dams. He obtained his Ph.D. under the supervision of Dr. Zhenyue Ma. He was a postdoctoral research fellow at POWERCHINA Huadong Engineering Corporation Limited, Hangzhou, China, from 2009-2011, and focused on the seismic stability analysis of high concrete arch dam.



## DR. HAIBIN ZHANG, MISSOURI S&T

**INSPIRE Project:** UAV Enabled Measurement for Spatial Magnetic Field of Smart Rocks in Bridge Scour Monitoring, **Research Advisor:** Dr. Genda Chen

Dr. Haibin Zhang is currently a visiting scholar in Dr. Genda Chen's INSPIRE UTC research group at Missouri S&T. Dr. Zhang received his B.S. in civil engineering in 2009 from China Agricultural University. After completion, he was recommended for admission to Dalian University of Technology's Master's program in September of 2009. In 2010, he enrolled in the doctoral program for a Ph.D. in disaster prevention and reduction engineering and protective engineering. His doctoral research focused on piezoelectric smart aggregated-based seismic stress monitoring and model updating for reinforced concrete (RC) structures. In 2016, he obtained his Ph.D. under the supervision of Dr. Jinping Ou (Member of Chinese Academy of Engineering) and Dr. Shuang Hou. He joined Harbin Institute of Technology (Shenzhen) in 2017 and focused on seismic damage monitoring of RC structures.

**FOR MORE INFORMATION, VISIT-**

[inspire-utc.mst.edu/researchprojects/](http://inspire-utc.mst.edu/researchprojects/)

# AT A GLANCE

# INSPIRE

INSPECTING AND PRESERVING INFRASTRUCTURE THROUGH ROBOTIC EXPLORATION

## RESEARCH

**13** research projects

- 3 ROBOTIC PROTOTYPES
- 1 ROBOTIC TRAINING SIMULATOR

## EDUCATION

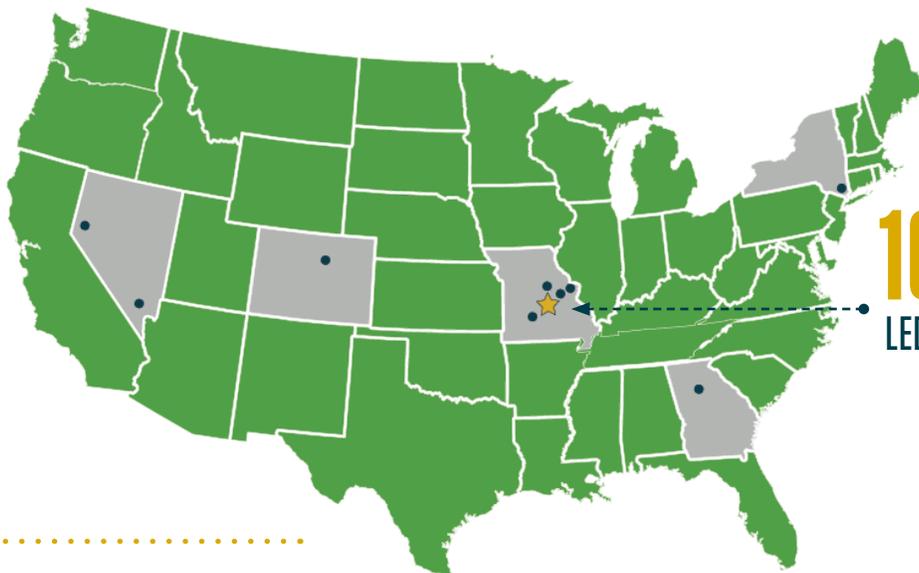
**41** students engaged in transportation research

- 19 GRADUATE
- 22 UNDERGRADUATE

## WORKFORCE DEVELOPMENT

**1,163** outreach participants

**5** STATES COVERED  
**156** CONTACT HOURS



## TECHNOLOGY TRANSFER

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# 9th International Conference on Structural Health Monitoring of Intelligent Infrastructure

## TRANSFERRING RESEARCH INTO PRACTICE

**AUGUST 4-7, 2019**  
St. Louis, Missouri USA  
Hyatt Regency at the Arch



### 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)
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### QUESTIONS? Our team is available to assist you!

#### TECHNICAL

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

SHMII-9 Conference Chair  
573-341-4462 | [gchen@mst.edu](mailto:gchen@mst.edu)

Sreenivas Alampalli, Ph.D., P.E., F.ASCE, F.SEI

SHMII-9 Conference Co-Chair  
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## PLAN TO ATTEND

### First time held in the USA

SHMII-9 represents the 9th official event in the biennial conference series sponsored by the International Association of Structural Health Monitoring of Intelligent Infrastructure (ISHMII). This is the first time the conference will be held in the USA. The State of Missouri is honored to host attendees of this prestigious conference. We hope you will bring your family and explore our state beyond St. Louis. Missouri is well known for its natural riverways, springs and caves. Other favorite vacation destinations include Branson and the Lake of the Ozarks.

[visitmo.com](http://visitmo.com)

### 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](http://stlouisarch.hyatt.com)

We look forward to welcoming each of you to St. Louis. For more information, visit:

[shmii-9.mst.edu](http://shmii-9.mst.edu)





## INSPIRE University Transportation Center

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# UPCOMING EVENTS

## TECHNOLOGY TRANSFER

**DECEMBER 10, 2018**

INSPIRE Webinar: Assistive Intelligence (AI): Intelligent Data Analytics Algorithms to Assist Human Experts, presented by Dr. Zhaozheng Yin, Missouri S&T, Rolla, MO

[inspire-utc.mst.edu/webinars](http://inspire-utc.mst.edu/webinars)

**JANUARY 13-17, 2019**

Transportation Research Board (TRB) Annual Meeting, Washington, D.C.

[tradeshows.com/trb](http://tradeshows.com/trb)

[inspire-utc.mst.edu/events](http://inspire-utc.mst.edu/events)

## OUTREACH

**JANUARY 12, 2019**

Missouri State Future City Competition, hosted by the Kaleidoscope Discovery Center and Future City Competition- Missouri, Missouri S&T, Rolla, MO

[futurecity.org](http://futurecity.org)

**FEBRUARY 22-24, 2019**

National Society of Black Engineers (NSBE) Pre-College Initiative Weekend, Missouri S&T, Rolla, MO

[sdi.mst.edu/precollege](http://sdi.mst.edu/precollege)

**FEBRUARY 24, 2019**

FLL Junior Expo, hosted by the Kaleidoscope Discovery Center, Missouri S&T, Rolla, MO

[thekaleidoscope.org/first-robotics](http://thekaleidoscope.org/first-robotics)