Quarterly Progress and Performance Indicators Report:
Project Number and Title: 1.6 Progressive fault identification and prognosis of railway tracks based on intelligent inference
Research Area: #1 Transportation infrastructure monitoring and assessment for enhanced life
PI: Jiong Tang, Department of Mechanical Engineering, University of Connecticut
Co-PI(s): N/A
Reporting Period: 1/1/2022 – 3/31/2022
Submission Date: 3/31/2022

Overview:

In this phase of research, we start to finalize the robust decision making capability of the proposed project. The major highlights are

- examining the noise/uncertainty effect to fault identification algorithms based on simulated data with artificial noise and actual experimental data of piezoelectric impedance;
- fine tuning the robust, probabilistic based damage identification framework.

Meeting the Overarching Goals of the Project:

The research highlights mentioned above benefit the project goals and objectives because

- the proposed multi-objective optimization based damage identification algorithm utilizing piezoelectric impedance can successfully identify structural damage, and the algorithm robustness can ensure the practical usage of the sensor hardware and the associated algorithms;
- ensuring hardware and software robustness can significantly reduce the false alarms.

Accomplishments:

The accomplishments achieved under the project goals are

- comprehensive case studies of system performance under various levels of noise/uncertainties to offer implementation insights;
- algorithm enhancement that can yield improved robustness of the system.

Task, Milestone, and Budget Progress:

Complete the following tables to document the work toward each task and budget

Table 1: Task Progress

Task Number: Title	Start Date	End Date	% Complete
Task 1: Sensing mechanism development	10/1/2018	9/30/2019	100%
Task 2: Sensor-node energy harvesting	10/1/2019	3/31/2020	100%

Task 3: Sensor networking strategy	4/1/2020	12/31/2021	100%
Task 4: Highly accurate and robust decision making	1/1/2022	6/30/2022	85%
Phase 1 Overall	10/1/2018	6/30/2022	85%
Phase 2 Overall	10/1/2021	9/30/2023	15%
Phase 3 Overall	N/A	N/A	N/a

Table 2: Milestone Progress

Milestone #: Description	Corresponding Deliverable	Start Date	End Date
Milestone 1: Sensing mechanism development	New sensor design	10/1/2018	9/30/2019
Milestone 2: Sensor-node energy harvesting	Energy harvesting design	10/1/2019	3/31/2020
Milestone 3: Sensor networking strategy	Networking criteria	4/1/2020	12/31/2021
Milestone 4: Highly accurate and robust decision making	Inverse analysis	1/1/2022	6/30/2022

Table 3: Budget Progress

Project Budget	Spend – Project to Date	% Project to Date (include the date)
$254,000	$241,300	95%

Is your Research Project Applied or Advanced?

☐ **Applied** (*The systematic study to gain knowledge or understanding necessary for determining the means by which a recognized and specific need may be met.)*

☒ **Advanced** *(An intermediate research effort between basic research and applied research. This study bridges basic (study to understand fundamental aspects of phenomena without specific applications in mind) and applied research and includes transformative change rather than incremental advances. The investigation into the use of basic research results to an area of application without a specific problem to resolve.)*

Education and Workforce Development:

Answer the following questions (N/A if there is nothing to report):

1. Did you provide any workforce development or training opportunities to transportation professionals (already in the field)? If so, what was the training? When was it offered? How many people attended? (i.e. The research team provided an in the field training for the SAR technology for 3 maintenance crew members of the MassDOT on 3/31/2021. The members learned how to use the technology and interrupt the data.)
   N/A
2. Did you hold meetings with any transportation industry organizations or DOTs? If so, what was the meeting's purpose? When was it offered? How many people attended? (i.e. The research team held a meeting with MaineDOT to update them on the progress of the research findings and how the findings can be implemented on 3/31/2021. 15 DOT maintenance members were present at the meeting.)
   N/A

3. Did you host/participant in any K-12 education outreach activities? If so, what was the activity? What was the target age/grade level of the participants? How many students/teachers attended? When was the activity held? (i.e. 25 8th graders and 2 teachers visited the concrete lab and created small concrete trinkets like Legos on 3/31/2021. They learned about the different types of fibers that can be used in the concrete.)
   N/A

Technology Transfer:

Use the table below to complete information about conference sessions, workshops, webinars, seminars, or other events you led/attended where you shared findings as a result of the work you conducted on this project:

Table 4: Presentations at Conferences, Workshops, Seminars, and Other Events					
Type	**Title**	**Citation**	**Event & Intended Audience**	**Location**	**Date(s)**
i.e. Conference, Symposium, DOT/AOT presentation, Seminar, etc.					
N/A	N/A	N/A	N/A	N/A	N/A

Use the table below to report any publications, technical reports, peer-reviewed articles, newspaper articles referencing your work, graduate papers, dissertations, etc. written as a result of the work you conducted on this project. Please list only completed items and exclude work in progress.

Table 5: Submitted/Accepted Publications, Technical Reports, Theses, Dissertations, Papers, and Reports				
Type	**Title**	**Citation**	**Date**	**Status**
Conference	Structural Damage Identification using Inverse Analysis through Optimization with Sparsity	2022 SPIE Smart Structures & NDE Conference	02/10/2022	Submitted

Answer the following questions (N/A if there is nothing to report):

1. Did you deploy any technology during the reporting period through pilot or demonstration studies as a result of this work? If so, what was the technology? When was it deployed?
   N/A
2. Was any technology adopted by industry or transportation agencies as a result of this work? If so, what was the technology? When was is adopted? Who adopted the technology?
   N/A

3. Did findings from this research project result in changing industry or transportation agency practices, decision making, or policies? If so, what was the change? When was the change implemented? Who adopted the change?
   N/A
4. Were any licenses granted to industry as a result of findings from this work? If so, when? To whom was the license granted?
   N/A
5. Were any patent applications submitted as a result of findings from this research? If so, please provide a copy of the patent application with your report.
   N/A
6. Did industry organizations or DOTs provide cost-share (cash or in-kind) to your research during the reporting period? Who was the organization? Please provide an in-kind support invoice from the organization with your report (this is kept confidential and used for record keeping purposes only).
   N/A

Describe any additional activities involving the dissemination of research results not listed above under the following headings:

Outputs:

Definition: Any new or improved process, practice, technology, software, training aid, or other tangible product resulting from research and development activities. They are used to improve the efficiency, effectiveness, and safety of transportation systems. List any outputs accomplished during this reporting period:

- A systematic case study of system robustness assessment incorporating various levels of noise/uncertainties has been conducted for the new sensing system.

Outcomes:

Definition: The application of outputs; any changes made to the transportation system, or its regulatory, legislative, or policy framework resulting from research and development activities. List any outcomes accomplished during this reporting period:

- With proper tuning of inverse analysis algorithms, the new sensing system can yield outstanding robustness. A confidence-level based fault identification approach is formulated that can dramatically reduce labor cost involved in resolving false alarms.

Impacts:

Definition: The effects of the outcomes on the transportation system such as reduced fatalities, decreased capital or operating costs, community impacts, or environmental benefits. The reported impacts from UTCs are used for the assessment of each UTC and to make a case for Federal funding of research and education by demonstrating the impacts that UTC funding has had on technology and education. List any outcomes accomplished during this reporting period:

- The robust sensory network will lead to fundamental advancement in structural fault identification for metal-based structures subject to piezoelectric impedance sensing.

Participants and Collaborators:

Use the table below to list individuals (compensated or not) who have worked on the project other than students.

Table 6: Active Principal Investigators, faculty, administrators, and Management Team Members				
Individual Name & Title	**Dates involved**	**Email Address**	**Department**	**Role in Research**
Jiong Tang, Professor	10/1/18-present	jiong.tang@uconn.edu	Mechanical Engineering	PI

*Use the table below to list **all** students who have participated in the project during the reporting period. (This includes all paid, unpaid, intern, independent study, or any other student that participated in this project.)*

Table 7: Student Participants during the reporting period								
Student Name	**Start Date**	**End Date**	**Advisor**	**Email Address**	**Level**	**Major**	**Funding Source**	**Role in research**
				Email is not included in the external report and is only used for internal purposes.	(i.e. UG, MS, PhD)		(i.e. TIDC, Other university funds, , unpaid intern, etc.	What work are they conducting? Please be descriptive. Student research assistant is not enough info.
Yang Zhang	10/1/18	present	Jiong Tang		PhD	Mechanical Engineering	TIDC, NASA	Carry out sensor design and inverse analysis
Ting Wang	1/1/20	present	Jiong Tang		PhD	Mechanical Engineering	TIDC, NSF	Carry out energy harvesting and sensor networking analysis

Use the table below to list any students who worked on this project and graduated or received a certificate during this reporting period. Include information about the student's accepted employment during the reporting period or if they are continuing their students through an advanced degree.

Table 8: Students who Graduated During the Reporting Period			
Student Name	**Degree/Certificate Earned**	**Graduation/Certification Date**	**Did the student enter the transportation field or continue another degree at your university?**
N/A	N/A	N/A	N/A

Use the table below to list any students that participated in Industrial Internships during the reporting period:

Table 9: Industrial Internships			
Student Name	**Degree/Certificate Earned**	**Graduation/Certification Date**	**Did the student enter the transportation field or continue another degree at your university?**
N/A	N/A	N/A	N/A

*Use the table below to list **organizations** that have been involved as partners on this project and their contribution to the project during the reporting period.*

Table 10: Research Project Collaborators during the reporting period						
Organization	**Location**	**Contribution to the Project**				
		Financial Support	**In-Kind Support**	**Facilities**	**Collaborative Research**	**Personnel Exchanges**
		List the amount	List the amount	Mark with an "x" where appropriate		
Sperry Rail Service	Shelton, CT				X	

*Use the table below to list **individuals** that have been involved as partners on this project and their contribution to the project during the reporting period.*

Table 11: Other Collaborators				
Collaborator Name and Title	**Contact Information**	**Organization and Department**	**Date(s) Involved**	**Contribution to Research**
Jan Kocur, Director of Engineering		Sperry Rail Service	10/1/2018 - present	Technical champion

Use the following table to list any transportation related course that were taught or led by researchers associated with this research project during the reporting period:

Table 12: Course List						
Course Code	**Course Title**	**Level**	**University**	**Professor**	**Semester**	**# of Students**
ME3220	Mechanical Vibrations	Undergrad	University of Connecticut	Jiong Tang	Spring 2022	89

Changes:

List any actual or anticipated problems or delays and actions or plans to resolve them (list no-cost extension requests here)…
N/A
List any changes in approach and the reasons for the change…
N/A

Planned Activities:

List the activities planned during the next quarter.

- The next phase of research will focus on the finalization of the entire sensing system development.