Quarterly Progress 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: 4/1/2021 – 6/30/2021
Submission Date: 6/30/2021

Overview: (Please answer each question individually)

In this phase of research, we continue working piezoelectric-based energy harvesting device that can re-charge the wireless sensor node by converting ambient vibration energy into electricity. This will maximize the autonomy of the sensory system. We also synthesize sensor networking strategy by synergizing fault detection and identification results.

Provide context as to how these activities are helping achieve the overarching goal(s) of the project…

The project vision is to develop robust and autonomous sensory network for railway tracks. One important issue in the sensory system is power supply. While the piezoelectric transducers employed in the sensing mechanism can in theory be concurrently employed for energy harvesting, there are practical challenges: 1) the size of piezoelectric transducers employed in the sensor is generally small with weak electro-mechanical coupling; and 2) train passage induced vibration are not simple harmonic. In this phase of research, we continue our exploration of mechatronic synthesis and optimization to maximize the energy harvesting efficiency. In particular, we have synthesized negative capacitance circuit that can effectively convert more vibratory energy into electrical power. Meanwhile, as the negative capacitance circuit is op-amp based which itself consumes power, an optimization is carried out to balance between fault detection and energy harvesting. We have designed and analyzed piezoelectric energy harvesting strategies. In particular, as train passage-induced. Another aspect of research that's being conducted in this phase of the research is to analyze the piezoelectric transducer characteristics under changing ambient conditions. We have systematically analyzed the impedance/admittance curve with respect to operating condition variations. This provides a foundation for damage detection sensitivity analysis which will be further employed in sensor networking synthesis.

Describe any accomplishments achieved under the project goals…

The major accomplishment in this phase of research is the trade-off investigation of energy harvesting device power consumption with respect to the net gain of power harvested and the impedance/admittance wide-band characteristics. This provides a set of design optimization strategies.

Complete the following tables to document the work toward each task and budget (add rows/remove rows as needed, make sure you complete the Overall Project progress row and include all tasks even if they have ended or have not been started)…

Table 1: Task Progress			
Task Number	**Start Date**	**End Date**	**% Complete**
Task 1:	10/1/2018	9/30/2019	100%
Task 2:	10/1/2019	3/31/2020	100%
Task 3:	4/1/2020	12/31/2021	70%
Task 4:	1/1/2022	6/30/2022	40%
Overall Project:	*Enter Actual Start*	*Enter Planned/Actual End*	

Table 2: Budget Progress		
Project Budget	**Spend – Project to Date**	**% Project to Date***

Include the date the budget is current to.

Describe any opportunities for training/professional development that have been provided…

This project has involved one M.S. student, Yixin Yao, who carries out the numerical and experimental investigations, and two Ph.D. students, Yang Zhang and Ting Wang, who focus on fault detection alotihm development and sensor synthesis with energy harvesting capability. Yixin Yao successfully defended his M.S. thesis in December 2020.

Describe any activities involving the dissemination of research results (be sure to include outputs, outcomes, and the ways in which the outcomes/outputs have had an impact during the reporting period. Please use the tables below for any Publications and Presentations in addition to the description of any other technology transfer efforts that took place during the reporting period.)… Use the tables below to complete information about conferences, workshops, publications, etc. ***List all other outputs, outcomes, and impacts after the tables*** *(i.e. patent applications, technologies, techniques, licenses issued, and/or website addresses used to disseminate research findings).*

Table 3: Presentations at Conferences, Workshops, Seminars, and Other Events

Title	Event	Type	Location	Date(s)
Presentation title	Name of event (i.e. TIDC 1st Annual Conference)	i.e. Conference, Symposium, Seminar,		
N/A				

Table 4: Publications and Submitted Papers and Reports

Type	Title	Citation	Date	Status
i.e. Peer-reviewed journal, conference paper, book, policy paper	Publication title	Full citation		I.e. Submitted, accepted, under review
N/A				

Encouraged to add figures that may be useful (especially for the website)…

Insert figures here

Participants and Collaborators:

Use the table below to list all individuals who have worked on the project.

Table 5: Active Principal Investigators, faculty, administrators, and Management Team Members

Individual Name	Email Address	Department	Role in Research
	Email is not included in the external report and is only used for internal purposes.		
Jiong Tang	jiong.tang@uconn.edu	Mechanical Engineering	PI

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

Table 6: Student Participants during the reporting period				
Student Name	**Email Address**	**Class**	**Major**	**Role in research**
	Email is not included in the external report and is only used for internal purposes.	(i.e. Junior, Master's Ph.D)		
Yang Zhang		Ph.D.	Mechanical Engineering	Carry out inverse identification research
Ting Wang		Ph.D.	Mechanical Engineering	Carry out energy harvesting research

Use the table below to list any students who worked on this project and graduated during this reporting period.

Table 7: Student Graduates			
Student Name	**Role in Research**	**Degree**	**Graduation Date**
N/A			

Use the table below to list organizations have been involved as partners on this project and their contribution to the project.

Table 8: Research Project Collaborators during the reporting period						
Organization	**Location**	**Contribution to the Project**				
		Financial Support	**In-Kind Support**	**Facilities**	**Collaborative Research**	**Personnel Exchanges**
Sperry Rail Service	Shelton, CT		X	X		

List all other outputs, outcomes, and impacts here (i.e. patent applications, technologies, techniques, licenses issued, and/or website addresses used to disseminate research findings). Please be sure to provide detailed information about each item as with the tables above.

Have other collaborators or contacts been involved? If so, who and how? (This would include collaborations with others within the lead or partner universities; especially interdepartmental or interdisciplinary collaborations.)

Table 9: Other Collaborators			
Collaborator Name and Title	**Contact Information**	**Organization and Department**	**Contribution to Research**
N/A			(i.e. Technical Champion)

Who is the Technical Champion for this project?
Name: Jan Kocur
Title: Director of Engineering

Organization: Sperry Rail Service
Location (City & State): Danbury, CT
Email Address: jkocur@sperryrail.com

Changes:

Discuss any actual or anticipated problems or delays and actions or plans to resolve them…
N/A
Discuss any changes in approach and the reasons for the change…
N/A

Planned Activities:

The next phase of the research will focus on the documentation of fault diagnosis development and then energy harvesting investigation.