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: 7/1/2020 – 9/30/2020
Submission Date: 9/30/2020

Overview: (Please answer each question individually)

In this phase of research, we finalize the development of the multi-objective optimization framework to facilitate damage detection and identification based on piezoelectric admittance measurement. A reinforcement learning based hyper heuristic algorithm is incorporated into multi-objective optimization. The new approach can rapidly identify various fault scenarios using actual sensor input. The unique feature is its capability of finding a more complete set of solution set that includes the actual damage scenario.

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

Our goal is to utilize computational intelligence to replace tedious, labor-intense, and error-prone manual inspection by human operators. The research activities accomplished in this phase of research provide enabling elements toward this goal. Fault scenarios usually cause very small changes in response measurements. At the same time, the inverse problem is generally under-determined, yielding multiple possible solutions. Therefore a significant challenge in fault detection and identification is to find a complete solution set that includes the actual fault scenario. Here we leverage upon reinforcement learning technique, an emerging computational intelligence approach, to realize inverse identification of damage scenario (location and severity). We have demonstrated that this solution technique indeed outperforms traditional approaches.

Describe any accomplishments achieved under the project goals…

The major accomplishment in this phase of research is the development of highly efficient and robust damage identification algorithm which can adequately utilize the new piezoelectric admittance sensor to facilitate decision making. The new approach can find a complete solution set that includes the actual damage scenario.

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:	09/2018	03/2020	100%
Task 2:	04/2020	03/2021	75%
Task 3:	03/2021	03/2022	20%
Task 4:	04/2022	09/2023	35%
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 one Ph.D. student, Yang Zhang, who focuses on improving the fault identification and prognosis algorithms. Starting in Fall 2020, Jan Kocur, the industrial collaborator in Sperry Rail Servce, has been re-activated as a Ph.D. student working with the PI on railway sensing technologies. The project progress is being communicated with industry collaborator, Sperry Rail Service, for training of state-of-the-art knowledge of active materials and advanced signal processing techniques for working professionals.

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,		
Deterministic Optimization for Damage Identification using Dividing Rectangles Algorithm	TIDC Annual Conference	Conference	Virtual	Aug 8, 2020

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)		
Yixin Yao		M.S.	Mechanical Engineering	Carry out simulation and experiment
Yang Zhang		Ph.D.	Mechanical Engineering	Carry out inverse identification

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 completion of fault diagnosis and then start energy harvesting investigation.