Quarterly Progress Report

TIDC Transportation Infrastructure Durability Center AT THE UNIVERSITY OF MAINE

Project Number and Title: 1.4 Electromagnetic Detection and Identification of Concrete Cracking in Highway Bridges
Research Area: Thrust 1: Transportation infrastructure monitoring and assessment for enhanced life
PI: Tzuyang Yu (UMass Lowell)
Co-PI(s): N/A
Reporting Period: 07/01/2021~09/30/2021
Date: 09/30/2021

Overview:

The research problem we are trying to solve is the structural assessment of aging concrete bridges (reinforced and prestressed) in New England, targeting at concrete cracking and degradation. Table 1 provides our progress on individual tasks. Table 2 reports our budget progress.

Table 1: Task Progress

Task Number	Start Date	End Date	Percent Complete
Task 3	9/1/19	8/31/21	70%
Task 4	9/1/19	9/30/21	90%
Task 5	1/1/20	9/30/21	90%

Table 2: Budget Progress

Entire Project Budget	Spend Amount	Spend Percentage to Date
$330,495 (federal)	$190,297 (federal)	57.6% (federal)

During the last quarter, we tested the developed portable SAR imaging sensor (see photos in last quarterly report 03/30/21) for its resolution in wireless communication to a laptop computer. A 3”-by-6” concrete cylinder was used in this experiment. Three different resolutions in the range direction were used (120 steps, 160 steps, and 200 steps) to understand how the increase of image resolution affects the quality of wirelessly transmitted SAR images. The experiment was conducted inside our radar lab on campus. The SAR imaging sensor and the laptop were separated by 6 ft (~ 2 m). Figure 1 shows the SAR images of the concrete cylinder at different range resolutions.

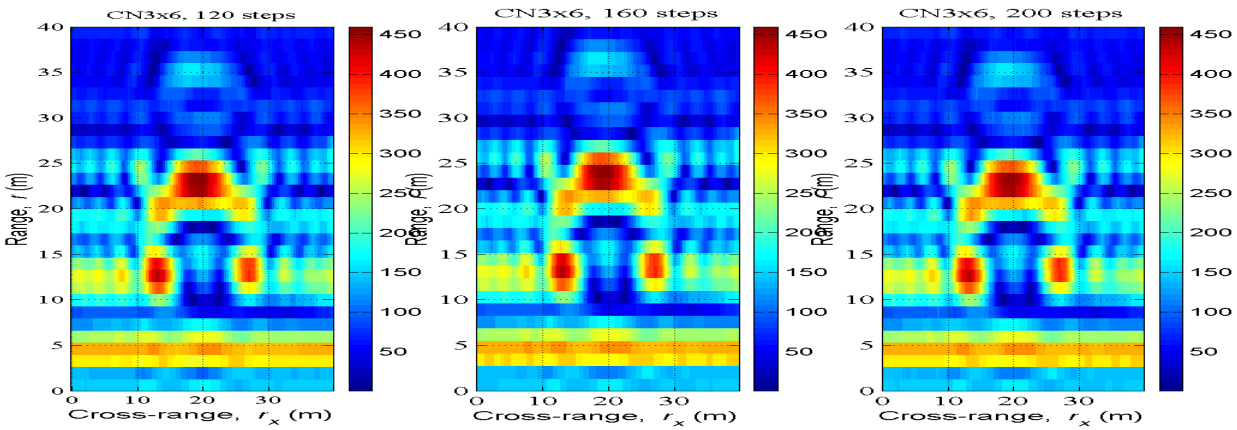

Fig. 1 **a)** Range resolution = 120 steps. **b)** Range resolution = 160 steps. **c)** Range resolution = 200 steps

In Figure 1, it appears that the increase of range resolution does not seem to be affected by the wireless communication between the radar sensor and the laptop computer. To better understand the difference in SAR images with different range resolutions, three SAR curves were extracted from Figure 1 and shown in Figure 2.

In Figure 2, it is clearly found that the 200-step range resolution provides more information about the concrete cylinder and is less vulnerable to ambient noise (less signal fluctuation).

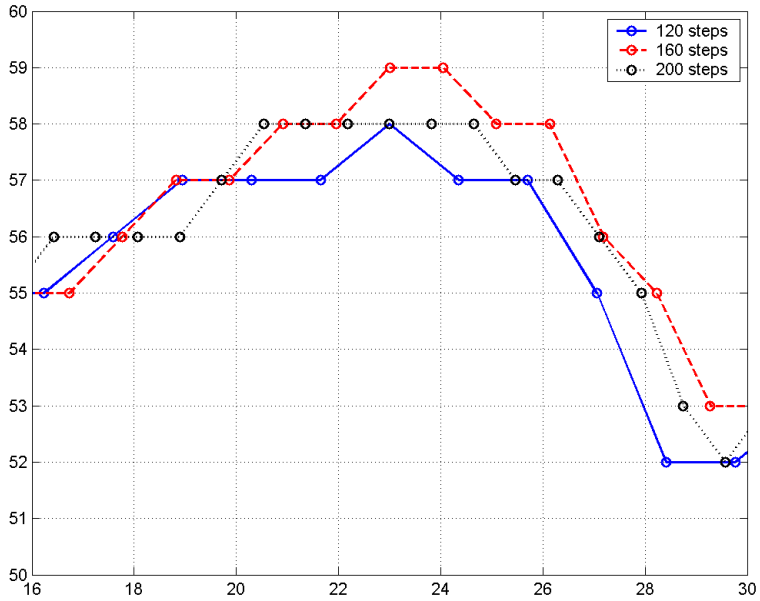

Fig. 2 Comparison of SAR image amplitude in different range resolutions.

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

Title	Event	Type	Location	Date(s)
Portable Synthetic Aperture Radar Imaging Sensor for UAV Bridge Inspections – Radar Principles	Online meeting with AI Engineers	Discussion on possible collaboration	Zoom meeting	August 8, 2021
Portable Synthetic Aperture Radar Imaging Sensor for UAV Bridge Inspections – Applications	Online meeting with AI Engineers	Discussion on possible collaboration	Zoom meeting	August 12, 2021
Remote Microwave Imaging for Moisture Gauging of Concrete Specimens	TCI (Taiwan Concrete Institute) 2021 Concrete Conference	Remote conference presentation	Kaohsiung, Taiwan	September 9, 2021 (*abstract submitted*)

Table 4: Publications and Submitted Papers and Reports

Type	Title	Citation	Date	Status
Journal paper	Electromagnetic detection of concrete cracking by using synthetic aperture radar and ground penetrating radar	NDT&E International	September 27, 2021	Under review
Journal paper	Remote Characterization of Chloride Content in Oven-Dried Concrete Specimens by using Synthetic Aperture Radar Image Models	Construction and Building Materials (CBM); doi.org/10.1016/j.conbuildmat.2021.124317	August 13, 2021	Vol. 302

Participants and Collaborators:

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

Individual Name	Email Address	Department	Role in Research
Tzuyang Yu	Tzuyang_Yu@UML.EDU	Civil and Environmental Engineering	Project principle investigator and Institutional Lead at UML; overseeing all projects and working on radar imaging and interpretation

Table 6: Student Participants during the reporting period

Student Name	Email Address	Class	Major	Role in research
Aiyad Alshimaysawee		Ph.D.	Civil and Environmental Engineering	Laboratory radar imaging and data processing
Sophe Ying		B.S.	Civil and Environmental Engineering	Assistance in the preparation for bridge field tests
Yaneliz Garcis Ruiz		B.S.	Civil and Environmental Engineering	Assistance in the preparation for bridge field tests
Tiana Robinson		B.S.	Civil and Environmental Engineering	Assistance in the preparation for bridge field tests

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
MassDOT	Boston, Massachusetts				X	X
City of Lowell	Lowell, Massachusetts				X	X
Geophysical Survey Systems, Inc. (GSSI)	Nashua, NH		X	X	X	X

Changes:

A new doctoral student, Mr. Aiyad Alshimaysawee, has joined the project in September 2021 as a doctoral-level research assistant in the Department of Civil and Environmental Engineering at UML.

Planned Activities:

In the next reporting period, we plan to continue following research tasks with limited access to our laboratories.
Task 3: Preliminary field radar imaging of concrete bridges
Task 4: Development of EM database
Task 5: Data analysis and image interpretation