TIDC Transportation Infrastructure Durability Center AT THE UNIVERSITY OF MAINE

Semi-Annual Progress Report

Project Number and Title: 3.8 Bridge Modal Identification via Video Processing and Quantification of Uncertainties
Research Area: Thrust 3 – New Systems for Longevity and Constructability
PI: Zhu Mao, University of Massachusetts Lowell
Co-PI(s): N/A
Reporting Period: 01/01/2019 ~ 03/31/2019
Date: 03/31/2019

Overview:

The project started a few months ago in researching the capability of applying computer vision analysis to magnify the motion captured by video cameras and identify the structural dynamics. The team has leverage the previous research on phase-based motion magnification to extract the modal information of a bridge in a portable, non-contact, and inexpensive way.

In order to obtain the modal information of bridge structures, video recording system has been set up and in-situ data are collected on a bridge close to UMass Lowell campus as an example. Figure 1 shows the location and view of the truss bridge, which is subject to ambient excitation induced by traffic, wind, scour, etc. The acquired data will be helpful in understanding the degradation of structural integrity reflected on the modal information so as to obtain the capability in portably and quickly assess the infrastructure condition.

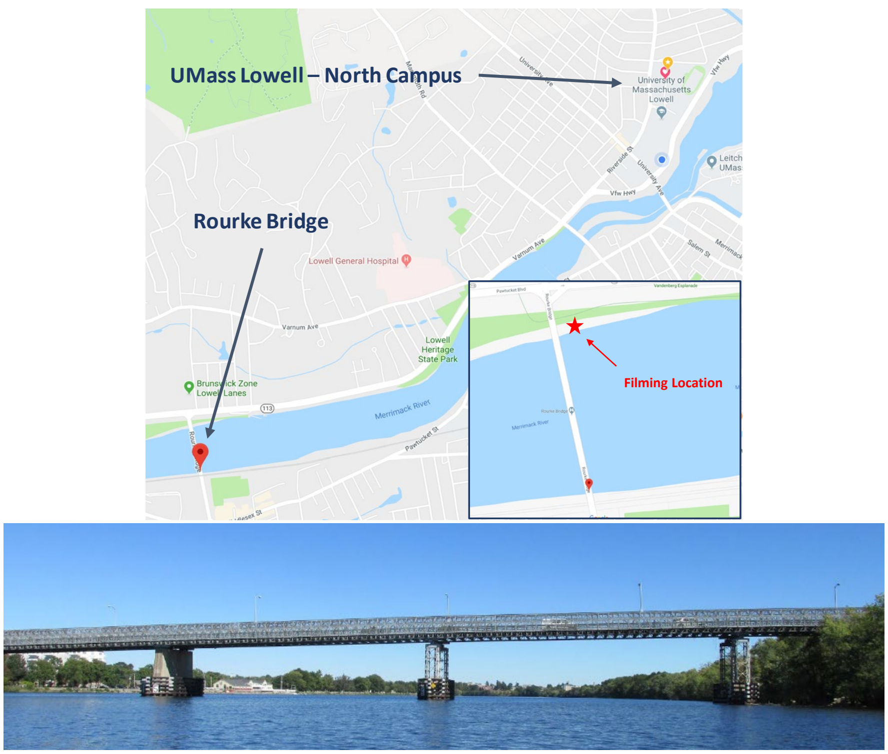

Figure 1: *Rourke bridge across Merrimack River* [1]

Videos have been recorded and processed in the past few months. The phase-based motion extraction algorithm is well reviewed and introduced in [2]. Preliminary analysis is carried out on the collected data at selected pixels. Figure 2 demonstrated the selected processed areas where high contrast is available. The selected pixels can be regarded as (mock) physically installed motion sensors, while in the non-contact computer vision approaches, the number of available measurement locations does not have to be small. By this means, the right span of the Rourke bridge is being considered and will be utilized for further analysis in the next reporting period.

Figure 2: *Recorded image/video data on Rourke bridge and selected pixels*

While processing the collected data in the frequency domain, the power spectrum of the bridge response is plotted as Figure 3 shows. There are some fundamental resonance frequencies observed. It is necessary to point out that the truss bridge is a complicated system and the peak at 2.3Hz is most likely the first bending mode. Peaks at lower frequencies could be other local vibrations coupled in, or other motion-like changes in the pixel data. There is a very interesting phenomenon that higher harmonics are observed with a modulation of roughly 4Hz. This is definitely needed to be identified in more details, and it could be caused by a lot of factors, such as nonlinearity, traffic/wind loading patterns.

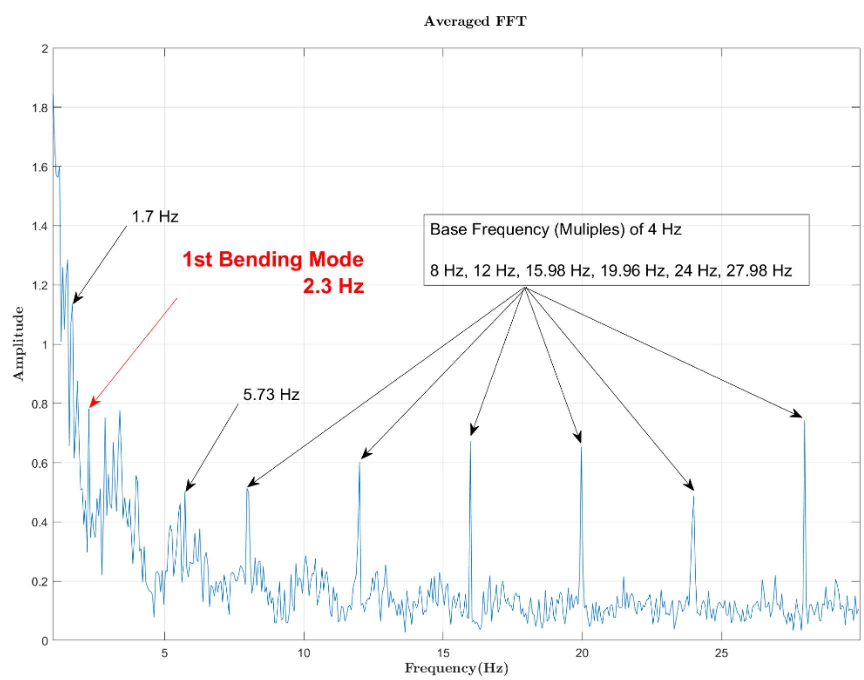

Figure 3: *Power spectrum of collected data at the selected pixels*

In the next reporting period, we will collect video data with better observability and the detailed plan is addressed in the section of "Planned Activities" later in the report.

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Participants and Collaborators:
The effort is leaded by Professor Zhu Mao, Department of Mechanical Engineering at University of Massachusetts Lowell, and there are a number of mechanical engineering graduate/undergraduate students participated.

Level	Name	Responsibility
Graduate	Aral Sarrafi	Theoretical investigation and supervision the tests
Undergraduate	Mark Todisco	Data acquisition, data processing, results visualization
Undergraduate	Brett Daniels	Data acquisition

Changes:

The project has been conducted in a smooth way and the current results reported in this reporting period demonstrate the capability of using phase-based video processing algorithms in identifying the structural dynamics. No significant changes were made in the past few months.

Planned Activities:

In the next reporting period, we will focus on the following challenges.

- The current location to set up video camera does not provide a good perspective of the bridge motion. We may need closer collaboration with DOT in finding a good and accessible spot with stable camera support. This will require a more direct, ideally perpendicular, filming angle as well as a good isolation from ambient ground motion, wind effect, etc.
- More in-depth investigation of selecting pixels, especially a big number of pixels to take advantage of the averages. By doing this, a better estimation of the modal information will be expected, but this is contingent on the data quality at the selected pixels. Trimming and cropping the videos prior to calculating the expected resonance frequencies may also help enhance the performance.
- Applying other sensing modalities, and maybe collaborating with other projects, in identifying frequencies using conventional data acquisition method. This will help design a better band-pass filter in getting mode shapes and motion magnification results.
- It is also planned to have a deeper understanding of the higher harmonics shown in Figure 3, after cross-validated using data from conventional data, and match the real motions with corresponding modes of the bridge.

References:

[1]. https://1.bp.blogspot.com/-EL9poJM9SSg/UjpWcoCMoNI/AAAAAAAAJ1E/T-JEVff893A/s1600/IMG_1350.JPG
[2]. Sarrafi, A., Mao, Z., Niezrecki, C. and Peyman, P., "Vibration-based damage detection in wind turbine blades using Phase-based Motion Estimation and motion magnification," Journal of Sound and Vibration, Volume 421, 12 May 2018, Pages 300-318