Bi-Monthly 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
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Co-PI(s): N/A
Reporting Period: 4/1/2019 – 5/31/2019
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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. Figure 1 below demonstrates the phased-based motion magnification to the videos captured at the Rourke bridge across Merrimack River in the last reporting period.

Figure 1: *Recorded image/video data on Rourke bridge and selected pixels*

A major challenge of such research effort is the selection of pixels and tracking the motion in certain areas in the video. Due to the poor observability, a lab-scale structure is adopted in this reporting period, to demonstrate the approach of identifying structural changes using the video-based motion extraction.

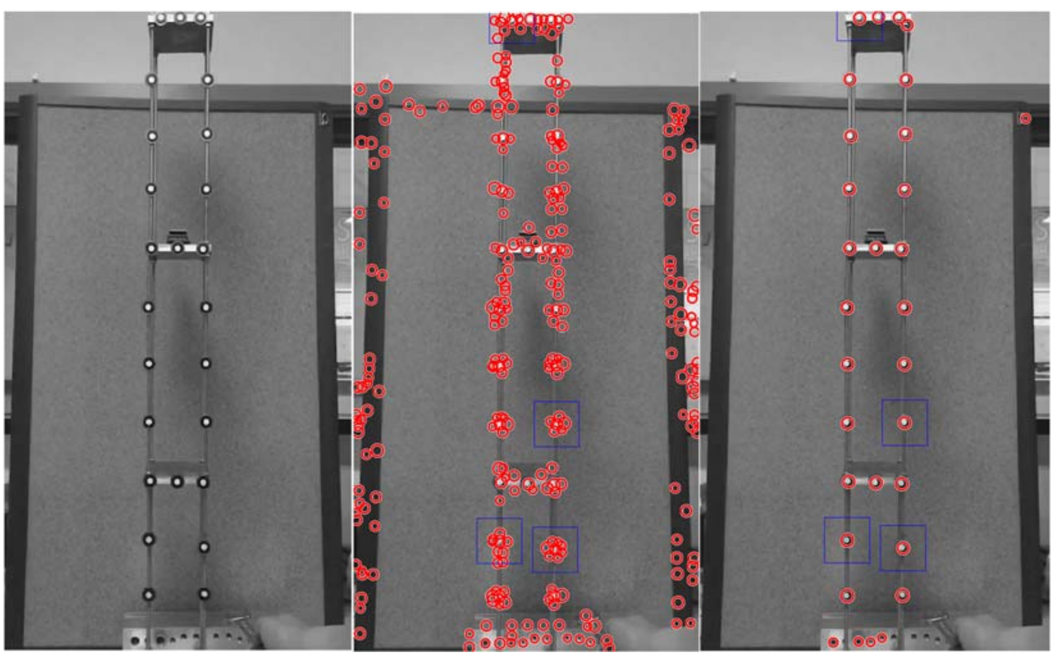

Figure 2: *contrived 3-story building structure. Left: original video frame; Middle: too many falsely tracked targets; Right: decent tracking of targets on components*

Figure 2 is a 3-story contrived building structure with targets on each component. Different amount of mass is allocated on each of the floor to simulate the change of loadings, i.e. system dynamics, and the goal of such set up is to test he feasibility of detecting and localizing "damages" through processing the video data. With a general Hough transformation for optical flow analysis, all the segments in the frame with high contrast in the pixel data are captured, as shown in the middle figure of Figure 2. However, there are too many false detections in the scope due to poor resolution. By applying more careful fine tuning of the parameters, and a better thresholding strategy, the targets are much more specifically captured, as shown in the right figure in Figure 2. To Enhance the data quality, a data augmentation algorithm is applied which segmentize the original video and each segment has 50% of overlap, so that more training cases are available.

The table below shows the summarized accuracy of each approach we tried in the past two months, and selecting a sparse set of targets with augmented data through overlapping outperforms the rest approaches.

Approach	Training Accuracy	Validation Accuracy	Approximate training time
Full-Field	99.39	95.25	1 Hour 15 mins
Selected Regions with Hough Transformation	100	96.32	8 mins
Selected Regions with Hough Transformation + Overlapping Data Augmentation	100	96.81	17 mins
Sparse Target Selection	100	97.54	8 mins
Sparse Target Selection + Data Augmentation	100	**98.68**	17 mins

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.