Bi-Monthly Progress Report:
Project Number and Title: 1.5 Distributed Fiber Optic Sensing System for Bridge Monitoring
Research Area: Thrust 1: Transportation infrastructure monitoring and assessment for enhanced life
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Overview:

The problem we are trying to solve is how to monitor deteriorated highway bridges using distributed fiber optic sensors. Fiber optic sensors are good candidates to monitor and inspect the structural health status of the bridges; therefore, they can provide useful data for the asset owners to prioritize of the maintenance and repair. Fiber optic sensors can provide fast and accurate measurements on strain and temperature over a long distance. With good packaging, they can function in harsh environments. Moreover, using the BOTDR (Brillouin Optical Time Domain Reflectometry) and the BOTDA (Brillouin Optical Time Domain Analysis) technologies on optical fibers, we can perform fully distributed sensing (e.g., spatial resolution of 1-m over 60-km distance) over a long range or a large area. The objective of this project is to develop fiber optic sensing cables using BOTDR (Brillouin Optical Time Domain Reflectometry) for monitoring highway bridges.

Accomplishment achieved :

We have developed a series of tests using the BOTDR and BOTDA mode to comprehend the functionality of the equipment as well as the performance of different fiber optic cables. The test was performed using 100-m long Corning fibers. One meter corresponding the fiber segment where the load is applied, and the rest correspond to two fiber spools of 69m and 32m. Figure 1 shows a sketch of the experiment set up. Weights were applied at one side of the fiber to simulate the change in the fiber tension. The changes in loading will correspond to a Brillouin frequency shift which will be related to a strain value. The difficulty of this approach is to be able to detect a small frequency shift. To overcome this problem different parameters such as Step Frequency, averages number, Window scan, and pulse rate must be chosen adequately to improve the resolution.

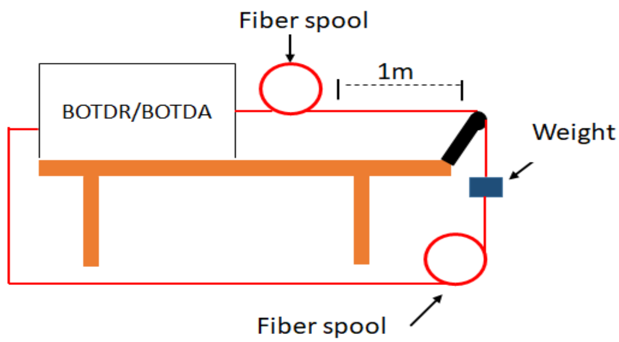


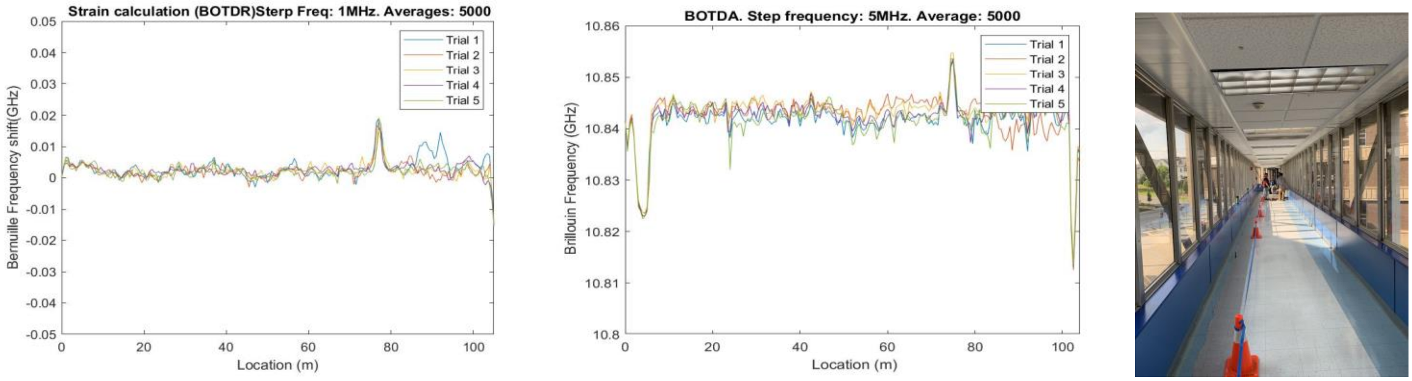
Figure 1: Experimental setup of optical fibers.

Two modalities (BOTDR and BOTDA) were used in this experiment. For each modality, we varied the parameters as shown in Table 1. Form this experiment, the best combination was chosen from both modalities (Figure 2). It is noteworthy to point out that every time the parameters need to be changed in order to accommodate specific needs of each test. The following findings were drawn from our experiment.

1. A low value for the step frequency will provide a much accurate measurement at the expense of the total scan time.
2. A high value for the averages number will provide a much accurate measurement at the expense of the total scan time.
3. Increasing the window scan will increase the total scan time and vice versa.
4. Increasing the pulse rate will decrease the total time scan and vice versa.
5. The total time of scan is subject the length of the fiber as well as the previous four points.

Table 1: List of Parameter used on the experiment

Step Frequency (MHz)	*Averages*	*Scan Window (GHz)*	*Pulse rate (MHz)*
0.1	*2000* *5000*	*10.8 to 11*	*25*
0.5			
1			
5			



(a) BOTDA result (b) BOTDR result (c) UML pedestrian bridge

Figure 2: BOTDA and BOTDR results

The result provided has allowed understanding better the mechanism in which the BOTDR/BOTDA machine works as well as the idea of using Brillouin scattering as a sensing system. These results also align with the overall goal of the project since a similar procedure will be implemented when the fiber is applied to infrastructure. For example, once the fiber is installed on a bridge the most appropriate parameters will have to be chosen depending on the level of sensitivity we would like to obtain. We also have selected one pedestrian bridge on the UML campus as a testbed for field tests. Shown in Figure 2 (c) is a picture of the pedestrian bridge with selected location for the installation of a BOTDR optical fiber sensor.

Opportunities for training：

During the reporting period, we have received the BOTDR training by Omnisens. This training consisted in the use and handling of the equipment as well as the software. Also, a conference paper abstract was submitted to the Asia-Pacific Optical Sensor conferences and it is now in the review process.

Participants and Collaborators:

During the reporting period, the following participants have worked on the project; Dr. Xingwei Wang (PI), Dr. Tzuyang Yu (co-PI), Mr. Jingcheng Zhou (doctoral RA), and Mr. Andres M.B. Vaccariello (doctoral RA). Collaboration with the MassDOT – We are continuing our collaborations with the MassDOT (Mr. A. Bardow).

Changes: None.

Planned Activities:

1. Test different fiber optic cable to determine which fiber is most suitable for the field test.
2. Install the cable on a Pedestrian bridge located at UMASS Lowell for the field test to validate the sensing system.