Data Fusion Based Structural Displacement Estimation Using Strain and Acceleration Measurements

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In structural health monitoring, it is very important to monitor displacement response which provides crucial structural information regarding structural integrity and its current condition. Although there are various displacement sensors, GPS is commonly used for displacement measurement since it can be easily installed and does not require a fixed reference point. However, GPS usually suffers with the low sampling rate and low accuracy problems, which limits its application to some degree. Efforts have been made on displacement estimation technique by fusing different types of sensors. For example, the two-stage Kalman filter was proposed to combine RTK-GPS and the accelerometer, thereby acquiring high accuracy displacement with high sampling frequency[1]. However, this technique cannot be used in GPS denied environments. Several studies also have combined strain and acceleration measurements to estimate displacement. When converting strains to the displacement, a power spectral density based method was used to estimate the neutral axis location. However, estimated neutral axis location usually had low accuracy for high-noisy measurements[2].

In this study, a displacement estimation method is proposed by FIR filter based fusion of measurements obtained from distributed strain sensors and single accelerometer. Firstly, the location of neutral axis is estimated based on the strain and acceleration measurements by utilizing Recursive Least Square (RLS) method. Then, the strain measurements is converted to the displacement with estimated neutral axis location. Finally, the high-fidelity displacement estimate is acquired by adopting the FIR filter to fuse acceleration measurement with converted displacement from strain measurements.

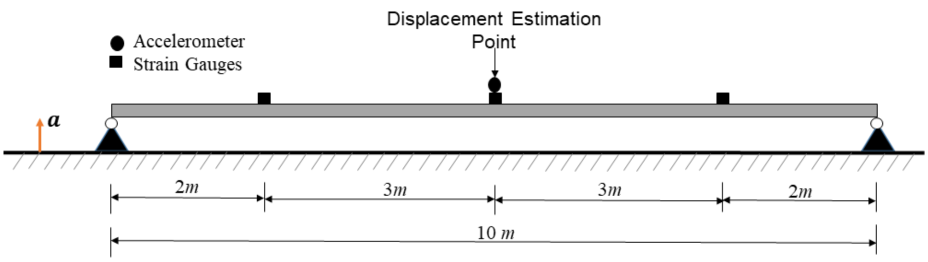

Fig. 1. The simply-supported beam model

The proposed displacement estimation method is examined by an numerical model of simply supported beam model under low frequency excitation. The model is shown in Fig. 1 and it has a square cross-section of 120 *mm* width. The layout of sensors is also shown in Fig.1. The reslut of the proposed method

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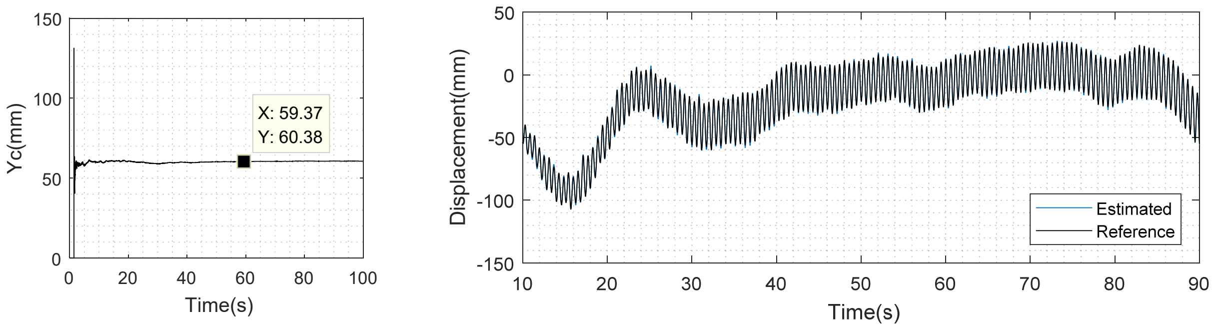
can be seen in Fig 2. It is clear that the estimated location of neutral axis is very close to the reference value which is 60*mm*. The estimated displacement also has a good agreement with the reference displacement and the root mean square error (RMSE) is only 1.07 *mm*.



(a) Neutral axis location (b) Estimated displacement

Fig. 2. The results of proposed displacement estimation method

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References

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