Simultaneous estimation of submerged floating tunnel displacement and mooring cable tension using accelerometer and strain gauge measurements

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Abstract. A submerged floating tunnel (SFT) is a tunnel structure that is floating around 50 m below the water surface and anchored to the seabed by morning cables. The SFT can be an attractive alternative to conventional bridges or immersed tunnels. Efforts to build SFTs are underway around the world. As part of these efforts, it would be necessary to develop a monitoring system to continuously evaluate the integrity of the SFT. In particular, the monitoring of tunnel displacement and mooring cable tension force would be critical to assess the structural integrity of the SFT. In this study, tunnel displacement and mooring cable tension force are simultaneously estimated by fusing accelerometer and strain gauge measurements. First, displacement is estimated from multi-point strain measurements using simplified mode shapes and mode scaling factors without requiring true mode shapes of the SFT. Here the mode scaling factors are automatically estimated using initial strain and acceleration measurements. The estimated displacement from the strain measurements is then fused with single-point acceleration measurement using a finite impulse response filter to obtain a final displacement with higher accuracy. In addition, the tension force of a mooring cable is estimated from the displacement at the connection between the tunnel and the mooring cable. The feasibility of the proposed technique was examined through a series of numerical simulations and a laboratory test on an 8-m-long aluminum SFT mock-up structure.

Keywords: Displacement estimation, tension force estimation, submerged floating tunnel, finite impulse response filter, strain gauge, accelerometer, data fusion.