

# Structural displacement estimation through multi-mode sensor fusion under GNSS denied environments

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In this presentation, three different sensing data fusion techniques are presented to estimate structural displacement in GNSS-denied environments.

- (1) An acceleration and strain based displacement estimation technique is developed for structures with no nearby fixed target by fusing accelerometer and strain gauge. The primary contribution lies in the simultaneous estimation of displacement and an unknown parameter associated with strain-displacement transformation, and improvement of displacement estimation accuracy.
- (2) An acceleration and vision camera based displacement estimation technique is developed for structures moving in-plane relative to a nearby fixed target by fusing accelerometer and vision camera. The primary contribution lies in the automated scale factor estimation, development of an adaptive multi-rate Kalman filter to fuse asynchronous acceleration and vision measurements, and improvement of feature matching by developing an ROI updating algorithm and two automatic mismatch rejection algorithms.
- (3) An accelerometer and radar based displacement estimation technique is developed for structures moving out-of-plane relative to a nearby fixed target by fusing accelerometer and FMCW mmWave radar. The primary contribution lies in the automated selection of the best target and estimation of a conversion factor for radar system, and improvement of radar-based displacement estimation by developing an acceleration-aided phase unwrapping algorithm.

A suit of numerical and experimental tests are performed to showcase these displacement estimation techniques.