Robust Adaptive Terrain-Relative Navigation
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Terrain-Relative Navigation (TRN) is an emerging technique for localizing a vehicle (e.g. AUV, UAV, or UGV) with respect to terrain. TRN offers a means of augmenting an inertia navigation system/Doppler velocity log (INS/DVL) dead-reckoned solution with continuous position fixes based on correlations with pre-stored maps. However, TRN algorithms can converge to incorrect solutions when operating for extended times over featureless terrain. Specifically, the TRN filter can become overconfident in an incorrect position fix.

This work demonstrates that the cause of these false fixes in information-poor regions is the assumption that the terrain is spatially uncorrelated, and offers a modification to the algorithm that can eliminate these false-fixes. The modification is based on adapting the filter weighting to depend on the estimated terrain information, which in addition to map error and sensor error provides a more robust TRN solution. The approach is an extension of work on robust adjusted likelihood ratios in the statistics community, and adjusts the variance of the filter to account for the impact of using the un-correlated assumption. This adaptive technique demonstrates convergence consistent with the amount of information present in the terrain.

This work focuses on the application of TRN to underwater vehicles. TRN accuracy on the order of 3m has been demonstrated in recent field trials using MBARI’s Dorado-class AUVs in Monterey Bay, but false fixes have been observed when operating over flat terrain. The effectiveness of the modified TRN algorithm is demonstrated using field data from MBARI AUV runs over flat terrain in Monterey Bay.