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Relative Kinematics Estimation Using Accelerometer Measurements

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ABSTRACT

For a network of mobile nodes, the problem of estimation of relative kinematics, given pairwise distances between the nodes, has received limited attention in literature. In this context, relative kinematics includes relative position, relative velocity and other higher order kinematic parameters defined with respect to a common frame of reference within the network. For numerous application domains in engineering, the nodes are highly dynamic, making the estimation task much harder. To solve the estimation problem uniquely, conventional methods either require the positions of some nodes of the mobile network to be known [2] or impose rigid body constraints on the mobile network [3]. These conditions limit the scope of proposed methods. Given a network of mobile nodes and time-varying pairwise distance measurements, we introduce a time-varying Grammian-based data model under the assumption that the mobile nodes have polynomial trajectories. Using the results in [4] and [5], estimators are proposed to estimate the relative kinematic parameters. Furthermore, we consider a scenario where the nodes have on-board accelerometers and the mobile nodes are holonomic. Under such assumtpions, the proposed data model is extended to include these accelerometer measurements, leading to improvements in relative kinematics estimation. We conduct simulations to showcase the performance of the proposed estimators, which show improvement against state-of-the-art methods.

Results and Discussion: Simulations are carried out for a network of 10 mobile nodes. In the comparison shown in Figure 1, the mobile nodes are assumed to be moving with constant velocity. The root-mean-sqaure-error (RMSE) of the relative kinematic parameters show improvement against the state-of-the-art (SOTA) in [3] for varying number of data points used, denoted by K. Figure 2 shows the RMSE errors on the relative kinematic parameters when the mobile nodes are assumed to be moving with a constant acceleration and each node is equipped with an accelerometer. The red curve shows the RMSE on the relative kinematics using the extended data model that fuses the accelerometer measurements with the originally proposed data model, shown in blue. The fusion of accelerometer measurements shows significant improvement in RMSE for the relative kinematic estimates.

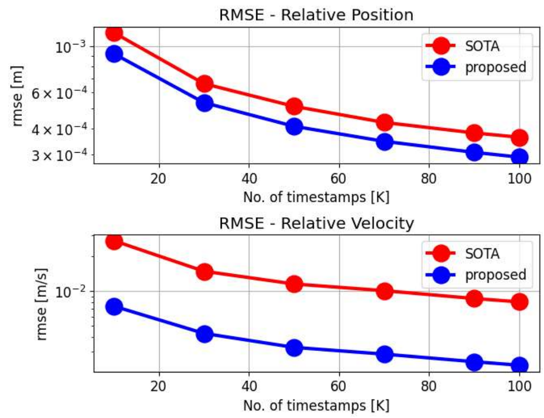

Fig. 1. Constant velocity case - RMSE on the relative kinematic estimates for varying K

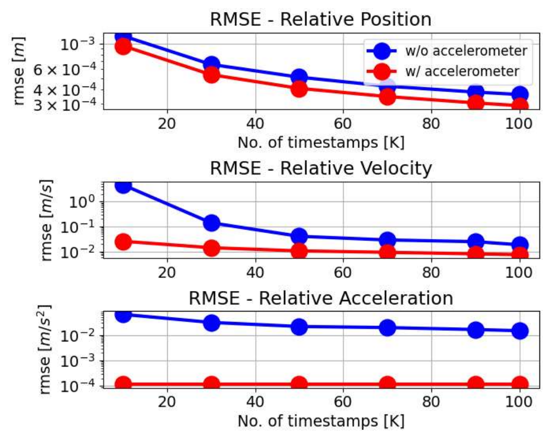

Fig. 2. Constant acceleration case - RMSE on the relative kinematic estimates for varying K with and without accelerometer measurements

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