Identification of the most conservative stability bounds for a class of multi-rate haptics controllers

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Abstract: This work identifies the most conservative stability bounds applicable to a class of multi-rate haptics controllers that involve sampling of a single state variable at two distinct rates for rendering a virtual wall. In particular, the uncoupled stability boundaries of a *dual-rate haptics controller* have been determined. In contrast to the prior research, the current work extends the scope in terms of identification of the impedance parameters that establish the worst-case stability limits that are closest to the experimental results. Our analysis reveals that the transformation sequence 'ZOH-Tustin-ZOH' yields the most conservative, while the 'half-sample delay approximation' approach yields the least conservative estimates of the stability bounds. Specifically, the relative root-mean-square error (RRMSE) between the experimental outcomes and the results predicted by the 'ZOH-Tustin-ZOH' transformations vary between 0.54–0.83, while for the 'half-sample delay approximation' it varies from 1.21–3.2, respectively.

Keywords: multi-rate controllers; impedance haptic interfaces; stability bounds.

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