ABSTRACT

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The extremum seeking control aims to converge and maintain the output of an unknown nonlinear mapping on its extreme point (optimal point). In this work, we present a Gradient-based extremum seeking algorithm for maximizing unknown maps in the presence of constant delays. It is corporated a filtered predictor feedback with a perturbation-based estimate for the Hessian of locally quadratic maps. Exponential stability and convergence to a small neighborhood of the unknown extremum point are achieved by using backstepping transformation and averaging theory in infinite dimensions. The low-pass filter (with a high enough pole) in the predictor feedback allows the technical application of the Hale and Lunel's averaging theorem for functional differential equations and also establishes an inverse optimal result for the closed-loop system. This inverse optimality property is for the first time demonstrated in extremum seeking designs and justifies the heuristic use of a low-pass filter between the demodulation and the integrator, which has historically been a part of the extremum seeking implementations free of delays.

Keywords: Inverse Optimality. Time Delay. Extremum-seeking. Adaptive Control. Predictor. Averaging in infinite dimensions.