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MEAN-SQUARE JOINT STATE AND NOISE INTENSITY ESTIMATION FOR LINEAR STOCHASTIC SYSTEMS

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Abstract. *This paper presents the mean-square joint state and diffusion coefficient (noise intensity) estimator for linear stochastic systems with unknown noise intensity over linear observations, where unknown parameters are considered Wiener processes. Designing the mean-square joint state and noise intensity estimator presents a significant advantage in the filtering theory and practice, since it enables one to address the mean-square state estimation problems for linear systems influenced by stochastic disturbances with an unknown variable noise level and, in addition, to construct the mean-square estimate for the noise intensity. The original problem is reduced to the filtering problem for an extended state vector that incorporates parameters as additional states. Since the noise intensities cannot be observable in the original linear system, the new quadratic vector variable formed by the diagonal of the matrix square of the system state is introduced. The obtained mean-square filter for the extended state vector also serves as the optimal identifier for the unknown parameters. Performance of the designed mean-square state filter and parameter identifier is verified in an illustrative example.*
Keywords: Filtering, Parameter identification, Linear stochastic system

1. **Introduction.** The problem of the optimal simultaneous state estimation and parameter identification for stochastic systems with unknown parameters has been receiving systematic treatment beginning from the seminal paper [2]. The optimal result was obtained in [2] for a linear discrete-time system with constant unknown parameters within a finite filtering horizon, using the maximum likelihood principle (see, for example, [18]), in view of a finite set of the state and parameter values at time instants. The application of the maximum likelihood concept was continued for linear discrete-time systems in [11] and linear continuous-time systems in [10]. Nonetheless, the use of the maximum likelihood principle reveals certain limitations in the final result: a. the unknown parameters are assumed constant to avoid complications in the generated optimization problem and b. no direct dynamical (difference) equations can be obtained to track the optimal state and parameter estimates dynamics in the "general situation", without imposing special assumptions on the system structure. Other approaches are presented by the optimal parameter identification methods without simultaneous state estimation, such as designed in [9, 7, 26], which are also applicable to nonlinear stochastic systems. Robust approximate identification in nonlinear systems using various approaches, such as H_∞ filtering, is studied in a variety of papers [4, 5, 8, 12, 13, 14, 15, 16, 19, 20, 21, 22, 23, 24, 25] for