Factorized Kalman Filtering

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Abstract: The paper deals with the Kalman filtering in the factorized form. The target application area is the urban traffic control, which main controlled variable – queue length, expressing the optimality of a traffic network most adequately, is directly unobserved and has to be estimated. Additional problem is that some state variables are of a discrete-valued nature. Thus, estimation of mixed-type data (continuous and discrete valued) models is highly desirable. A potential solution to this problem calls for a factorized version of the state-space model, which describes respective state factors individually. The application to Gaussian state-space model and Gaussian observations provides well-known Kalman filter [1]. This task is addressed in the paper.

The importance of the problem is obvious. The urban traffic systems are overloaded almost everywhere: the cars move slowly and inefficiently through towns within permanently extending peak hours. Adequate extension of the traffic network is expensive and often impossible, especially in historical towns. It calls for exploiting all available means starting from economical pressure, various regulative measures up to exploitation of modern, ideally adaptive, feedback control.

The problem has been already considered in several previous papers. The work [2] was directed exactly at the estimation of the individual state factors under Bayesian methodology [3] and proposed the recursive algorithm of factorized filtering. But it required a special, reduced, form of the state-space model, which caused excessive restrictions. The paper [4] proposed the solution, based on applying the chain rule to the state-space model, without

such a restriction. The present work considers the problem of the factorized filtering with Gaussian models and offers the solution, based on applying the $L'DL$ decomposition of the covariance matrix. The result of such a filtering is the posterior state estimate with the mean value and the factorized matrix of covariance.

References

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