X Triennial International SAUM Conference
on Systems, Automatic Control and Measurements
Niš, Serbia, November 10th-12th, 2010

Robust Kalman Filter as Parameter Estimator for Output Error Models

V. Filipovic and V. Stojanovic

Department of Energetics and Automatic Control, University of Kragujevac, Faculty of Mechanical Engineering Kraljevo, Dositejeva 19, 36000 Kraljevo, Serbia, E-Mail: vfilip@eunet.rs

Abstract ***- The data in industry are corrupted with stochastic noise. In the real situations data contain outliers which can create problems to linear algorithms. Because, some kind of prevention must be taken into account. So are developed robust procedures for parameters estimation. In this paper we shall consider output error model and for robust parameters estimation the Masreliez-Martin's robust filter is used. This filter is generalization of Kalman filter. In this paper we***

(i) ***eliminate the transformation factor***

(ii) ***nonlinear Masreliez-Martin prediction error transformation we replace with Huber function***

(iii) ***Fisher information is replaced with derivative of Huber's function***

(iv) ***generation of input signal (experiment design) is based on ideas from predictive control***

Also, the intensive simulations are performed.

Key words: ***Nongaussian noise, output error model, robust Kalman filter, experiment design***

I. INTRODUCTION

One of the problems that appears in the area of identification of industrial processes is the identification in the presence of stochastic disturbance. Practical studies show that disturbance, in general, has non-Gaussian distribution. It is an especially important case when appears inconsistent, in relation to the main part of population, observations (outliers). Probability distributions for this case are approximately normal (ε -contaminated) and they are the subject of intense research in mathematical statistics. For such a case, we consider the robust procedures for parameters estimation.

The reason for which we decided to use output error (OE) type recursive algorithm for parametric identification is that it can provide good performance when the plant output measurement is disturbed by noise. This can be explained by the fact that the output of this predictor does not directly depend upon the measured variables disturbed by noise, as the case with prediction error type predictor. The output of this predictor depends indirectly upon the measurements through the adaptation algorithm but this dependence can decrease in time by using a decreasing adaptation gain [1-2].

We will apply the robust filter theory for solving problem of the robust parameter estimation. In 1960, Kalman introduced an effective algorithm to realize the optimum filter for Gaussian processes, [3]. The Kalman filter works well, but it assumes that the system model and noise statistics are known. If any of these assumptions are violated then the filter estimates can degrade. This was noted early in the history of Kalman filtering [4-5].

Although the Kalman filter is the optimal linear filter, it is not the optimal filter in general for non-Gaussian noise. Noise in nature is often approximately Gaussian but with heavier tails, and the Kalman filter can be modified to accommodate these types of density functions [6-8].

Masreliez [6] found that the score function for the residual process plays an important role in obtaining the minimum variance estimator. However, the procedure to evaluate the score function involves convolution operations which are difficult to implement. Facing this difficulty, Masreliez and Martin [7] applied the influence function of min-max robust theory [9-10] to replace the score function. They first use the linear transformation to scale and symmetrize the density of the residual process and then operate on the result with an influence function to cut off the outliers in the noise distribution.

Nevertheless, several basic disadvantages are associated with the Masreliez-Martin filter:

- The estimator requires the unknown contaminating distribution to be symmetric. This is a stringent requirement, since in practice one would not expect departures from normality to be symmetric. Without the assumption of symmetry, the estimator may not be consistent.
- In general, there are relatively long periods of time in which noise is essentially Gaussian so that it is important to maintain full efficiency during these periods. Yet their estimator cannot work as well as the standard Kalman filter does in Gaussian noise.
- For various forms of measurement noise, the achievable optimum Cramer-Rao bound of point estimation (Kalman filtering without plant noise) is different. This estimator is optimal not in the efficiency-robust sense (approaches the Cramer-Rao bound), but in the min-max sense (minimizes the maximum variance) within those specific models such as the ε -contaminated family Φ_{ε} for a fixed mixing parameter ε [9] or a p-point family model Φ_p with a fixed p [10], respectively.

Because of these disadvantages, authors have decided to make some modification of the robust filter proposed by Masreliez and Martin [7].