Am Alternative Identification Approach to ARGESIM Comparison C15 'Clearance Identification' using MATLAB

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Simulator: MATLAB is commonly used software, which allows easy vector and matrix manipulation and rapid prototyping. Version 6.5 of MATLAB, in conjunction with the Optimization Toolbox, was used for simulation as well as parameter identification of the given model.

Model: The system of differential equations was solved analytically with some help of MATLAB's symbolic toolbox and then coded in MATLAB functions. In order to implement the bolus injection correctly, the homogeneous ($f(t)=0$) and inhomogeneous systems were solved separately and connected at $t = \tau$.

Task a - Simulation of the System. For the three different bolus injections, Table 1 and Figure 1 show the results, calculated by evaluation of the analytic solution functions.

$\tau_1 = 0.5$	$\tau_2 = 3$	$\tau_2 = 240$
$x_1(1.5) = 320.90$	$x_2(4.5) = 302.58$	$x_3(240) = 145.26$

Table 1: Values of x_1 for different bolus injections

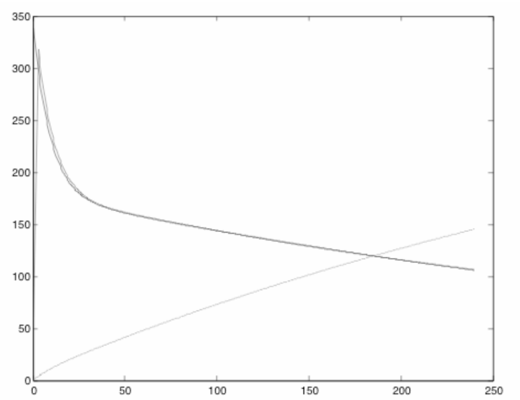

Figure 1: Simulation results for different τ

Task b –Identification. For identification, an alternative approach for measuring the error was used. The main idea was to make use of the Euclidean distance in $\boldsymbol{R}^2$ instead of $\boldsymbol{R}^1$ for constructing the error criterion, thus also allowing for inaccuracy in time instants. Therefore the usually used criterion E_p was replaced by $E_{p,s}$:

The hidden parameters s_i were introduced for modelling the normal distance.

$$E_p = E(\vec{p}) = \sum_{i=1}^{n} (c(t_i;\vec{p}) - c_i)^2$$

$$E_{p,s} = E(\vec{p},\vec{s}) = \sum_{i=1}^{n} ((c(t_i;\vec{p}) - c_i)^2 + (s_i - t_i)^2$$

$$\vec{p} = (k_{01}, k_{12}, k_{21}, V_1) \quad \textit{parameters}$$

$$\vec{s} = (s_1, s_2, \ldots, s_n) \quad \textit{hidden parameters}$$

$$(c_i, t_i) \;\; 1 \le i \le n \quad \textit{measurements}$$

There is no local minimum of $E_{p,s}$ as long as the points on the graph of $c(t)$, belonging to the time values s_i , do not represent locally closest points to (c_i ,t_i). The minimization of $E_{p,s}$ for p_i and s_i was done using MATLAB's function `lsqnonlin` (Levenberg-Marquardt algorithm).

The resulting parameters are k_{01} =0.0031, k_{21}=0.0244, k_{12}=0.0385, and V_1=8.67. The resulting maximum of c was 286.34, clearance 26.7 and the residuum 109.68. Figure 2 shows the resulting plot of $c(t)$.
The blue crosses mark the measurements; the red crosses mark the identified values of (s_i, $c(s_i)$). Confirming our considerations, these identified values nearly gave the points were the normal distances are reached.

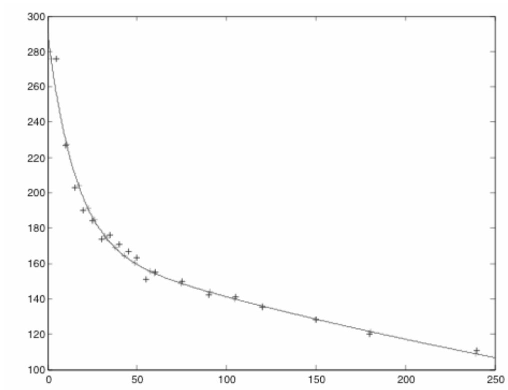

Figure 2: Measurements and identified function

Task c- Error Estimation. Data are disturbed by adding random vectors, for each set of disturbed data the identification procedure is performed. Results after 1000 identifications are given in Table 2

	k_{01}	k_{12}	k_{21}	V_1
mean	0.00308	0.03853	0.02488	8.63667
std.dev.	0.00036	0.00486	0.00352	0.20756

Table 2: Statistics for identification of parameters with disturbed measuments

C15 Classification: Analytical / numerical Approach, Alternative Identification
Version: MATLAB Rel 13 SP2