Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium, Volume 21, No. 1, ISSN 1726-9679
ISBN 978-3-901509-73-5, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2010
Make Harmony Between Technology and Nature, and Your Mind will Fly Free as a Bird
Annals of DAAAM International

RECURSIVE IDENTIFICATION ALGORITHMS LIBRARY IN MATLAB&SIMULINK

NAVRATIL, P[avel] & IVANKA, J[an]

Abstract: *This paper presents simple SIMULINK library for recursive parameter estimation of linear dynamic models ARX, ARMAX and OE. Several recursive identification methods were implemented in this library: Least Square Method (RLS), Recursive Leaky Incremental Estimation (RLIE), Damped Least Squares (DLS), Adaptive Control with Selective Memory (ACSM), Instrumental Variable Method (RIV), Extended Least Square Method (RELS), Prediction Error Method (RPEM) and Extended Instrumental Variable Method (ERIV). To cope with tracking the time-variant parameters several forgetting factor and modification of basic algorithm are taken into consideration.*
Key words: *Recursive estimation, ARX models, ARMAX models, forgetting factors*

1. INTRODUCTION

There exist many complex packages for system identification purposes in MATLAB and SIMULINK environment. These toolboxes provide solution to wide range of the problems from the area of system identification, e.g. System Identification Toolbox (Ljung, 2004) and Continuous Identification Toolbox (Granier, 2006).

There also exist many special-purpose programs and libraries for MATLAB and SIMULINK, e.g. Idtool (Cirka & Fikar, 1998). These simple tools provide solution to specific problems from the concrete part of the area of system identification.

The proposed Recursive Identification Algorithms Library (RIA) fall into category of simple libraries for SIMULINK environment and is designed for recursive estimation of the parameters of the linear dynamic models ARX, ARMAX and OE. The Recursive Identification Algorithms Library consists of several user-defined blocks. These blocks implement several recursive identification algorithms: Least Square Method (RLS) and its modifications, Recursive Leaky Incremental Estimation (RLIE), Damped Least Squares (DLS), Adaptive Control with Selective Memory (ACSM), Instrumental Variable Method (RIV), Extended Least Square Method (RELS), Prediction Error Method (RPEM) and Extended Instrumental Variable Method (ERIV). The Recursive Identification Algorithms Library can be used for simulation or real-time experiment (e.g. Real Time Toolbox) in educational process when it is possible to demonstrate the properties and behaviour of the recursive identification algorithms and forgetting factors under various conditions and can be also used in the identification part of self-tuning controllers.

2. RECURSIVE PARAMETER ESTIMATION

The recursive parameter estimation algorithms are based on the data analysis of the input and output signals from the process to be identified. Many recursive identification algorithms were proposed (Ljung, 1987, Söderström & Stoica, 1989; Wellstead & Zarrop, 1991). In this part several well-known recursive algorithms with forgetting factors implemented in Recursive Identification Algorithms Library are summarized.

2.1 RLS

This method can be used for parameter estimate of ARX model. Standard RLS algorithm assumes that the parameters of the model process are constant. In many cases, however, the estimator will be required to track changes in a set of parameters. To cope with tracking the time-variant parameters some adjustment mechanism must be introduced in the basic equations. Several implementations have been proposed (Ljung, 1987; Söderström & Stoica 1989; Kulhavý & Zarrop 1993; Corriou, 2004; Wellstead & Zarrop 1991). In this work, fixed exponential forgetting, variable exponential forgetting and adaptive directional forgetting are taken into consideration.

2.2 DLS

Damped least squares (DLS) algorithm is an extended version of the recursive simple least square (RLS) algorithm (Lambert, 1987).

2.3 ACSM

Adaptive control with selective memory (Hill & Ydstide, 2004) updates parameter estimates only when there is new information present. The information increases and estimator eventually stops.

2.4 RIV

It can be shown that if the process does not meet the noise assumption made by the ARX model, the parameters are estimated biased and nonconsistent. This problem can be avoided using instrumental variable method (Söderström & Stoica, 1989).

2.5 ERIV

This method ensures improved accuracy and greater speed of convergence than RIV. The method is based on choice of instruments vector which has more elements than there are parameters in the model to be estimated. Derivation of this algorithm can be found in (Söderström & Stoica 1989). Instruments can be chosen according to (Branica et. al., 1996; Söderström & Stoica 1989).

2.6 RELS

This method is used for parameter estimations of ARMAX model. Formally it takes the same form as RLS. However, the regression and parameter vectors are different.

2.7 RPEM

The recursive prediction error method (RPEM) allows the online identification of all linear model structure. Since all model structure except ARX are nonlinearly parameterized, no exact recursive algorithm can exist; rather some approximations must be made (Söderström & Stoica 1989).

3. RECURSIVE IDENTIFICATION ALGORITHMS LIBRARY

The Recursive Identification Algorithm Library is designed for recursive parameter estimation of linear dynamics model ARX, ARMAX, OE using recursive identification methods: Least Square Method (RLS), Recursive Leaky Incremental Estimation (RLIE), Damped Least Squares (DLS), Adaptive Control with Selective Memory (ACSM), Instrumental Variable Method (RIV), Extended Least Square Method (RELS), Prediction Error Method (RPEM) and Extended Instrumental Variable Method (ERIV).

The Recursive Identification Algorithm Library is depicted in Fig. 1. The Library consists of 18 user-defined blocks and is designed for MATLAB&SIMULINK environment. Each block is realized as an s-function.

Each block is masked by user-defined dialog. Several necessary input parameters should be input through this dialog. These are: type of forgetting factor and its value, degrees of polynomials, sampling period, initial values of parameter estimate, covariance matrix and data vector, etc. Each block also contains the help describes the meaning of each parameter, inputs and outputs and used recursive identification algorithms.

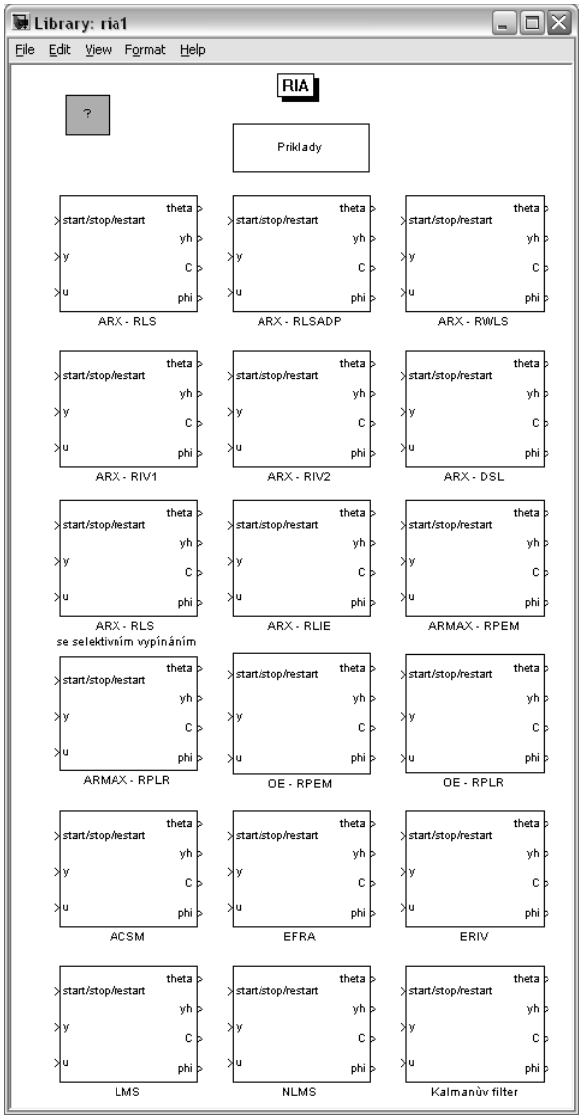

Fig. 1. Recursive Identification Algorithms Library

Input/output data from object under identification process are inputs to the identification block. Another input (start/stop/restart) is used for control the identification algorithm. This input provides possibility of start, stop and restart the identification algorithm in selected instant of time. Outputs of the block are estimate of parameter vector, one-step prediction of output of model, covariance matrix and data vector. The inputs and outputs of the block are shown in Fig. 2.

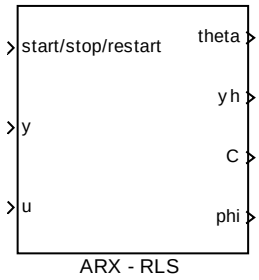

Fig. 2. Inputs/outputs of the identification block

4. CONCLUSION

The Recursive Identification Algorithm Library is designed for recursive parameter estimation of linear dynamics model ARX, ARMAX, OE using recursive identification methods. The library can be used e.g. in identification part of self-tuning controller or in educational process when it is possible to demonstrate the properties and behaviour of the recursive identification algorithms and forgetting factors under various conditions.

5. ACKNOWLEDGEMENTS

This work was supported by grant No. MSM 7088352102 of the Ministry of Education of the Czech Republic.

6. REFERENCES

Branica, I., N. Peric and I. Petrovic (1996). Comparison of Several Recursive Identification Methods. *Automatika*,Vol. 37, No. 3-4, (99-104)

Cirka, L. and M. Fikar (1998). *Identification tool for Simulink.* Department of Process Control, FCT STU, Technical Report KAMF9803

Corriou, J. P. (2004). *Process Control : Theory and Applications*. Springer-Verlag, London

Cunha, J. B., P.B. Oliviera, J.P. Coelho (2004). Recursive Parameter Estimation Algorithms. In: *Controlo 2004: 6th Portuguese Conference on Automatic Control*. (109-114)

Garnier, H. (2006). Continuous-Time System Identification Toolbox, *Available from*: http://www.iris.cran.uhp-nancy.fr/contsid/. *Accessed*: 2009-10-03

Hill, J.H. and B.E. Ydstie (2004). Adaptive control with selective memory. *International Journal of Adaptive Control and Signal Processing*, Vol. 18, No 7, (571-587)

Kulhavý, R. and M.B. Zarrop (1993). On a general concept of forgetting. *International Journal of Control*, Vol. 58, No. 4: (905–924)

Ljung, L. (1987). *System identification – theory for user.* Prentice-Hall, Englewood Cliffs, ISBN 0-13-881640-9, N.J

Ljung, L. (2004). System Identification Toolbox: For use with MATLAB. Prentice-Hall, Englewood Cliffs, N.J

Lambert, E. P. (1987). Process control applications of long-range prediction. DPhill thesis, University of Oxford

Nelles, O. (2001). *Nonlinear system identification. S*pringer-Verlag, ISBN 3-540-67369-5, Berlin

Söderström, T. & Stoica, P. (1989). *System Identification.* Prentice Hall, University Press, ISBN 0-13-881236-5, Cambridge

Wellstead, P.E. & Zarrop, M.B. (1991). *Self-Tuning System – Control and Signal Processing*, John Wiley & Sons Ltd., ISBN 0-471-92883-6, Chichester