

Adaptive Control Toolbox 1.0

for MATLAB® & Simulink®

Design and implement parameter identification and adaptive control schemes

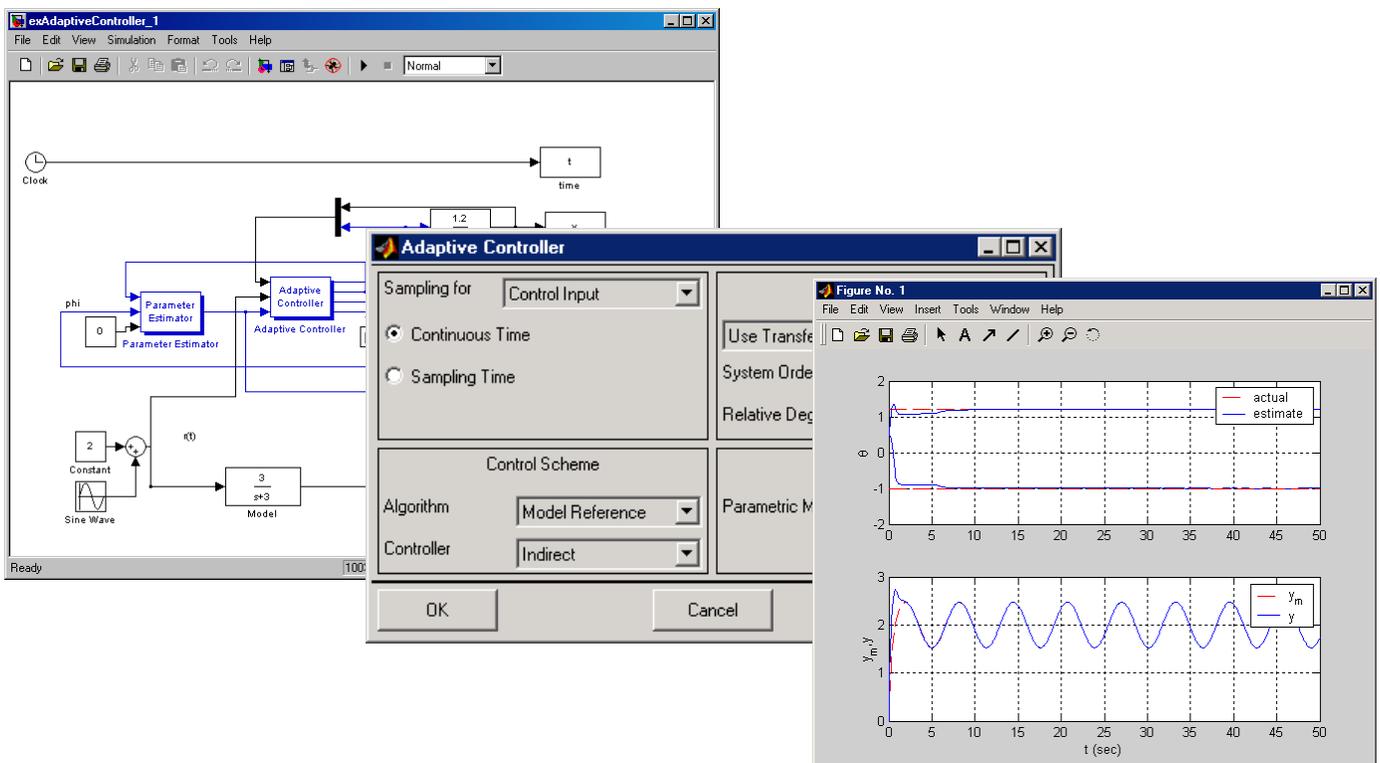
The Adaptive Control Toolbox, for MATLAB® & Simulink®, is an extensive toolbox to design, implement, and analyze parameter identification and adaptive control schemes. The design and implementation can be performed for both continuous-time and discrete-time plants.

Most of the widely-accepted algorithms in the adaptive control literature are provided in the toolbox. These include various gradient and least squares based parameter identification routines, model reference and pole placement adaptive control laws, parameter projection and robust modification algorithms, etc.

Toolbox features are provided in Simulink® blocks with user friendly GUIs as well as a set of MATLAB® commands. The Simulink® blocks offer easy implementation and design parameter selection with visual aids while the MATLAB® commands bring flexibility in specific and complex designs.

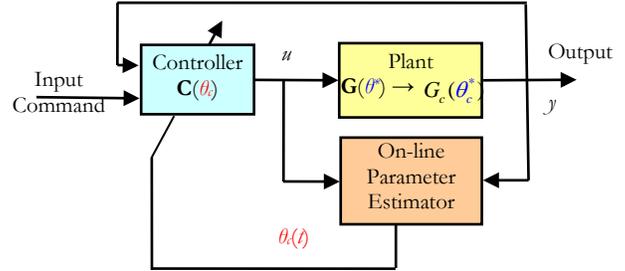
Key Features

- Numerical implementation of an extensive set of parameter identification and adaptive control schemes.
- Simulink® blocks with user-friendly GUIs to implement the schemes and to select/tune the design parameters easily.
- Ability to implement the same schemes using the provided MATLAB® commands in order to have flexibility in design and implementation.
- Applicability to both continuous-time and discrete-time plants.
- Normalization, parameter projection, and robust modification capabilities to guarantee stability and robustness.
- Basic polynomial algebra tools to design controllers based on model matching and pole placement techniques.



Parameter Identification

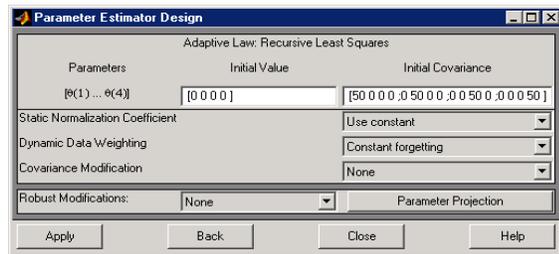
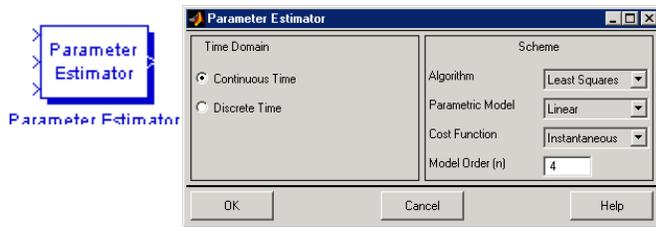
Parameter identification schemes are the backbones of adaptive control systems used to estimate the unknown parameters on line. The Adaptive Control Toolbox provides implementation of all the major parameter identification algorithms in the literature, including various types of gradient and least squares algorithms for both linear and bilinear parametric models. The plant to be identified/controlled can be continuous-time or discrete-time.



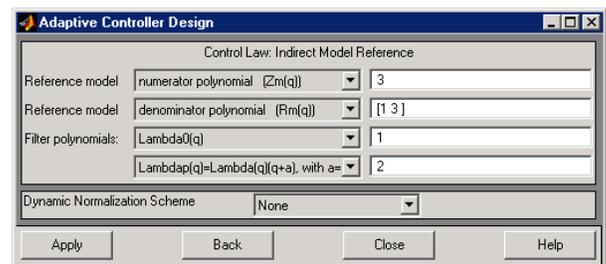
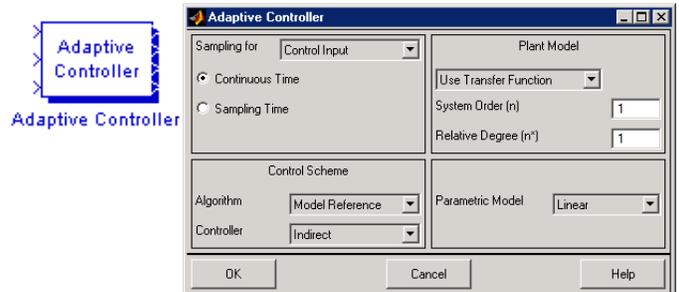
On-Line Parameter Identification and Adaptive Control

Adaptive Control

The Adaptive Control Toolbox provides various types of model reference, pole placement, and minimum prediction error control law routines for both continuous-time and discrete-time plants. These routines can be used to control plants with known parameters or combined with parameter identification algorithms to control plants with unknown parameters adaptively.



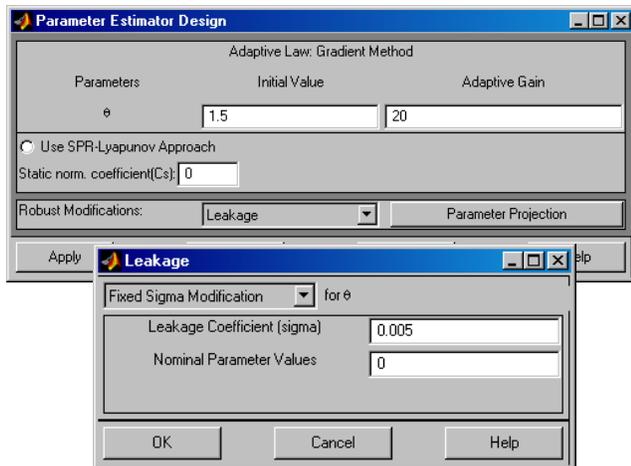
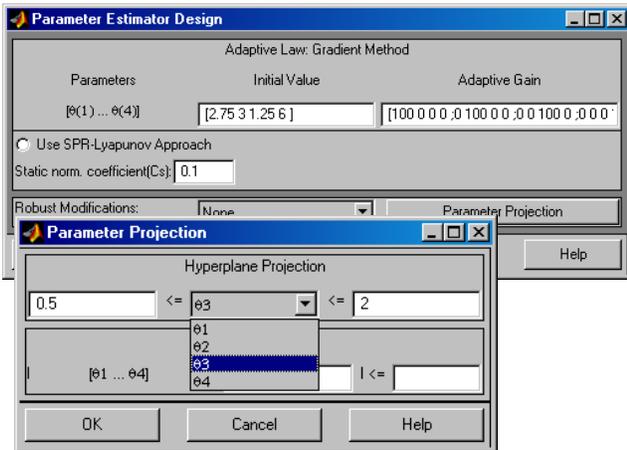
The parameter identification algorithms can be run using the Simulink® block **Parameter Estimator** and its GUIs. In these GUIs, the user may select the time domain (continuous-time/discrete-time), the parametric model (linear/bilinear), the type of the identification algorithm, the design parameters, etc. The user may select to use normalization, parameter projection, and various robustness modifications as well. If the objective is simply the identification of the plant parameters, the block **Plant Identifier** may be used instead. For plants represented by transfer functions or ARMA models, the corresponding parametric model signals feeding the estimator can be generated using the block **Parametric Model**. For more flexibility the user may prefer using the m-file commands of the toolbox.



The easiest way to use these routines is via the Simulink® block **Adaptive Controller**. In the GUIs of this block the user may choose the time domain, the control algorithm, the parametric model, design parameters, etc. Alternatively he/she may use the m-file commands in order to have more flexibility in more specific designs.

Normalization, Parameter Projection, Robustness Modifications

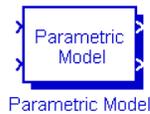
The three major issues in an adaptive control design are stability, robustness, and performance. The Adaptive Control Toolbox provides the implementation of the major tools in the adaptive control literature for guaranteeing stability and robustness. The normalization, parameter projection, and robustness modification tools can be used together with the parameter identification and adaptive control algorithms to design robust adaptive controllers. They can be accessed either using the GUIs of the **Parameter Estimator** and **Adaptive Controller** blocks or directly as m-file commands.



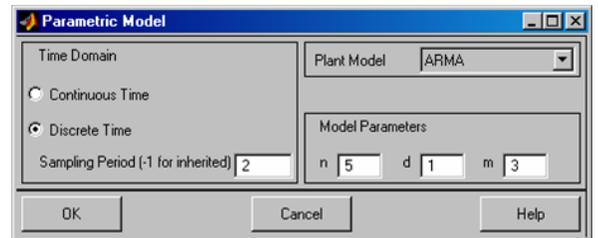
Model Conversions, Model Reduction, and Other Tools

Plant models can be described in various formats such as transfer functions, ARMA models, parametric models, etc. As a supplementary tool, the Adaptive Control Toolbox provides a set of model converters that can be used for adaptive control design. Another supplementary tool provided in the toolbox both as a Simulink® block and a command-line function is for model reduction. This tool can be used for adaptive control designs for plants with partially known parameters.

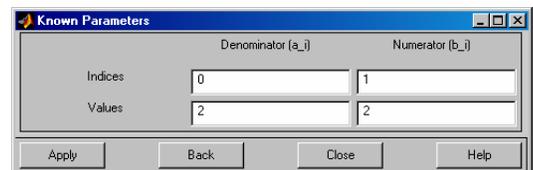
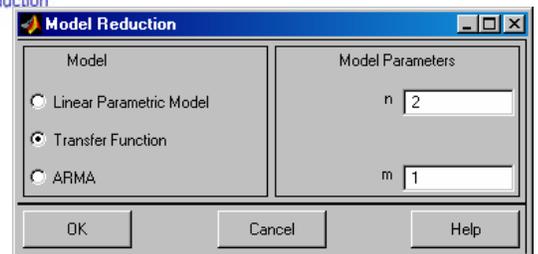
The Adaptive Control Toolbox brings several other gadgets that are widely used in adaptive control designs. These include the polynomial algebra tools, output predictors, implementation of certain filters and observers that are suitable for adaptive control, etc.



Parametric Model



Model Reduction



Simulink® Blocks and Command-Line Functions

One particular benefit of the Adaptive Control Toolbox is the freedom of choosing the domain to work on. The Simulink® blocks may be used for easy and visual implementations, and the MATLAB® commands may be used to have more flexibility in specific adaptive control design tasks. Below is a partial list of the Simulink® blocks and the MATLAB® commands provided in the toolbox.

SIMULINK® BLOCKS

Adaptive Controller	Implement adaptive control schemes
Parameter Estimator	Implement parameter identification algorithms
Parametric Model	Generate parametric model signals
Plant Identifier	Identify the parameters of plant models
Model Reduction	Reduce the order of parametric models with partially known parameters

SAMPLE MATLAB® COMMANDS

Parameter Identification

ucgrad, ucgradbk, ucgradint	Continuous-time (CT) gradient algorithms
dgradb, dgradl, udgrad	Discrete-time (DT) gradient algorithms
ucrls, urlrsarg	CT least-squares algorithms
drls, udrls, urlrsarg	DT least-squares algorithms
dprojmod, dprojorth, dprojpure, udproj	DT projection algorithms

Adaptive Control

mrcpoly	Model reference control (MRC) design
umrcdrb, umrcdrl	Direct model reference adaptive control (MRAC)
umrcidr	Indirect MRAC
ppcpoly, uppcpoly	Pole placement control (PPC): Polynomial approach
ppclq, ppcssv, uppcrsf	PPC: State space & linear quadratic (LQ) approaches
dosac, udosacdr, udosacidr	DT one-step ahead control
dmpc, umpcdrl,	DT minimum prediction error

umpcidr, umpcsdr control

Adaptive Law Modifications

unmlize	Normalization
uparproj	Parameter projection
urobust	Robust modifications

Supplementary Tools

dprd, udprdr, udpridr	Output prediction
lo2lm, uarma2lm, uarma2oe, utf2lm	Model conversion
lmred	Model order reduction
bezout, diophant	Solve Diophantine polynomial equations
euclid, poly lcm	Find greatest common divisor and lowest common multiple of two polynomials
stateest, uobserve	State Estimation
uarma, ufilt	Filter implementations of ARMA and transfer function models

Compatibility and Requirements

The toolbox is compatible with MATLAB® R2008a through R2010a. The only required products are MATLAB® and Simulink®. The toolbox is self-contained and no other toolbox is required to be installed.

Authors and Contact Info

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