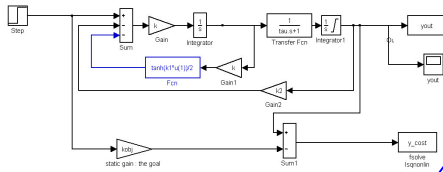# APPEDGE
Consulting&Engineering

Diffedge

Differentiation, sensitivity analysis and identification of hybrid Models
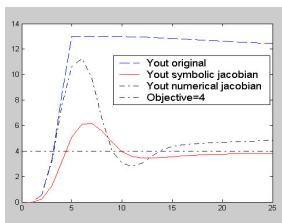
Diffedge calculates the symbolic derivative of the mathematical models
described in the form of block diagram under Simulink.

➢ Optimisation problem illustrating the *Diffedge* methodology

We want to optimise the guess parameters *k1,k2,k3*. The model includes a discontinuity (saturated integrator) and a strong nonlinear function in the loop. The model output is yout and the objective function is *y_cost*.

Diffedge syntax:
Diffedge('derivative','mymdl',{'k','k1','k2'})

The obtained symbolic derivative is also represented in graphic form (block diagrams) and can be used like any Simulink model. We remain in the Simulink environment.

Diffedge does not require any task of programming and modification of the model.

Derivative model with respect to *k,k1,k2*

> It combines the powerful of computer algebra system and block diagram structures for computing the derivative of a Simulink model with respect to the independent parameters.
> The derivative of cost and constraints can be also computed inside the Simulink model.

Zoom in symbolic derivative of block Fcn : tanh(k1*u)/2

The visualisation of the partial derivatives is possible for any coordinates of the model.
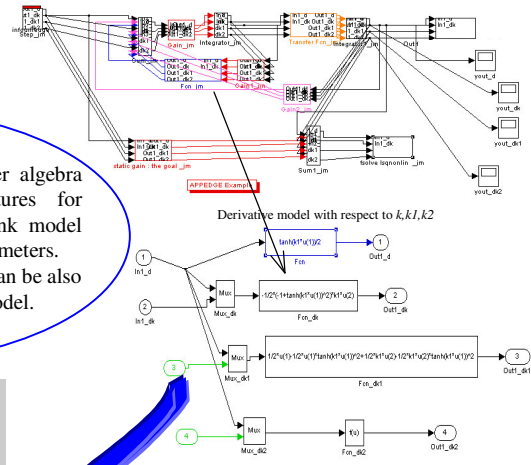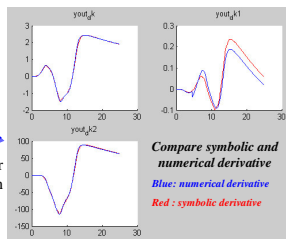
Compare optimisation with a symbolic and numerical jacobian

For the simulation of the derivative we can choose either variable-step or fixed-step solvers.

Diffedge embeds your optimisation routines with the derivative model.

Compare symbolic and numerical derivative
Blue: numerical derivative
Red : symbolic derivative

Diffedge is a new methodology that eliminates the drawbacks of finite-difference approximations and the complexity to use the automatic differentiation.

➢ Diffedge and analytic sensitivity analysis

Diffedge

In one simulation, *Diffedge* calculates :

$$L(Pi)=N(mi, \sigma i) \Rightarrow L(y(t))=N(m(t), \sigma(t))$$

We want to know the behaviour of the model output with respect to tuning parameters *k, k1, tau.*

Scheme of the second order symbolic derivative

k

k1

tau
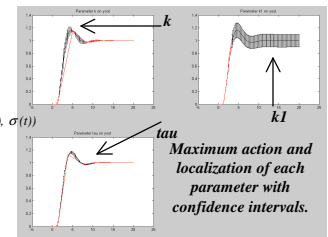
Maximum action and localization of each parameter with confidence intervals.

➢ Fields cover by *Diffedge* :
- Analytic sensitivity and statistical analysis,
- Optimisation and identification,
- Fault detection for system monitoring,
- Diagnostic and optimisation in real-time,
- Optimal, nonlinear, adaptive control,
- …

➢ Capabilities :
- *Diffedge* is already used in the industry. It computes a derivative model (600 blocks) with respect to 18 parameters in less than 3 minutes.

➢ Legend :
- *Diffedge* :Automatic Tasks

➢ User benefits :
- *No additional* programming is required and modification of the model.
- *Diffedge* is an automatic tool for optimisation problems and parametric sensitivity analysis**.**
- *Diffedge* is an useful tool for capitalizing on information and for understanding the behaviour of the model.
- *Diffedge* allows to apply several kinds of optimisation algorithms with constraints which necessitate to provide the gradient.
- …

➡ *Diffedge* **reduces product cost and facilitates innovation**.

➢ Contacts :
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➢ Examples of blocks processed with *Diffedge* :
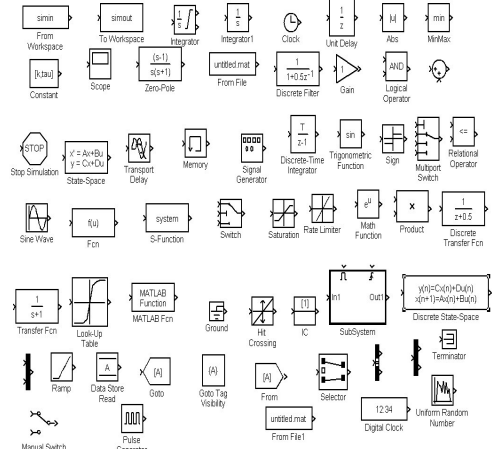
Matlab/Simulink, Optim and Extend symbolic toolboxes: are registred Trademarks of The Mathworks inc

Differentiation Edge