BLOM Quick Start Guide

MPC Lab
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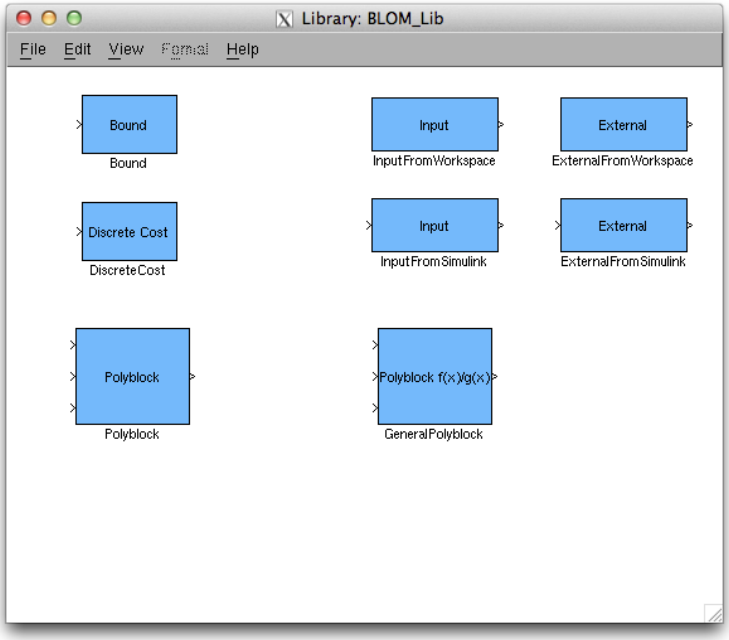
What is BLOM?

- Provides a graphical interface to allow users to create optimization problems using Simulink blocks.
- Exports mathematical model to solvers (eg. ipopt)
- Great for optimization problems with "dynamics" that evolve over time

$$\min_x f(x)$$
$$g(x) \leq 0$$
$$h(x) = 0$$

BLOM Library



Externals: Labels External Variables that can be changed via script or command line for different calls of the solver

Inputs: Labels Input Variables to be optimized by solver

Bounds: Sets upper/lower bounds on a variable

Cost: Cost variable to be minimized.

Polyblocks: BLOM's convenient way to create nonlinear functions

Polyblocks

BLOM's internal representation of blocks.

$$y_1 = 2x_1^2x_2, \quad y_2 = 3x_1 + x_2^4$$

$$P = \begin{bmatrix} 2 & 1 \\ 1 & 0 \\ 0 & 4 \end{bmatrix} \quad K = \begin{bmatrix} 2 & 0 & 0 \\ 0 & 3 & 1 \end{bmatrix}$$

$$y_1 = 2x_1 + 3sin(x_2), \quad y_2 = 3x_1^2e^{x_3} + 0.2tan(x_2)x_4^3$$

$$P = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \text{BLOM\_FunctionCode('sin')} & 0 & 0 \\ 2 & 0 & \text{BLOM\_FunctionCode('exp')} & 0 \\ 0 & \text{BLOM\_FunctionCode('tan')} & 0 & 3 \end{bmatrix}$$

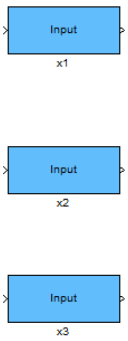
Setting Up BLOM on Your Computer

1. `http://mpclab.net/Trac/wiki/SVNsetup` Here are instructions on how to get SVN and how to get BLOM running
2. in command line, `svn checkout http://www.mpclab.net/BLOM/` desired_directory
3. Each time you open up BLOM, make sure to get the latest version by typing `svn update` within that folder (or update through TortoiseSVN)
4. On Mac or Linux machines, you may need to compile IPOPT and then run `BLOM_Setup` (Instructions for doing so at `http://mpclab.net/Trac/wiki/CompilingIpopt`)

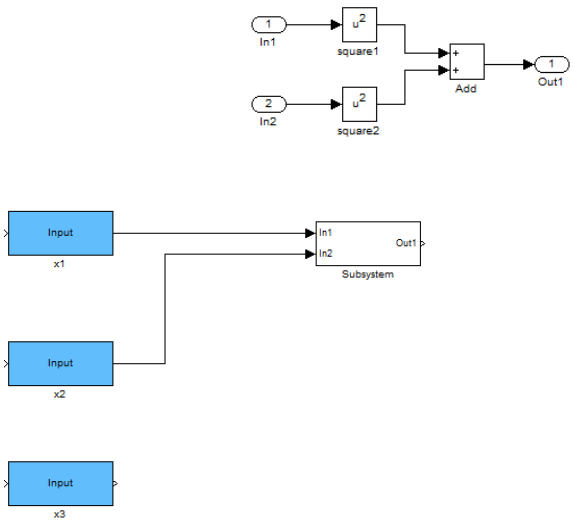
Creating Model Example

$$\max f(x) = 3x_1 + x_2 - x_3^2 + 2x_3$$
$$x_1^2 + x_2^2 \leq 5$$
$$x_1 - x_2 \leq 1$$
$$x_3 \geq 0$$

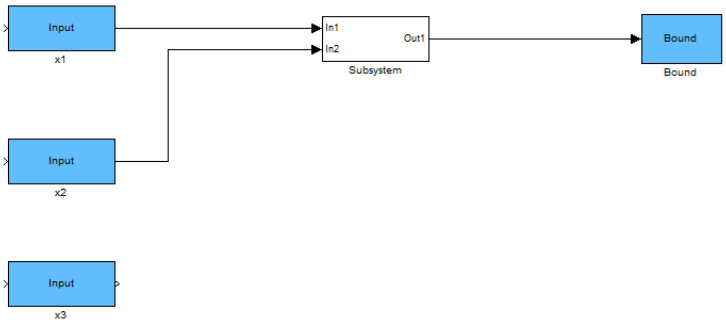
Step 1: Place Input and External Blocks for input and external variables

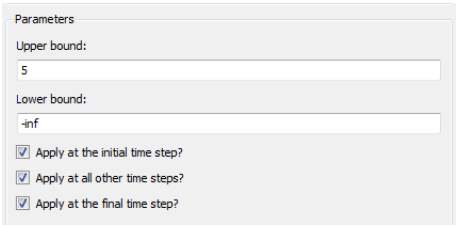


Step 2: For each bound limitation and cost function, drag and drop math blocks to satisfy equations. Use subsystems and/or polyblocks as needed

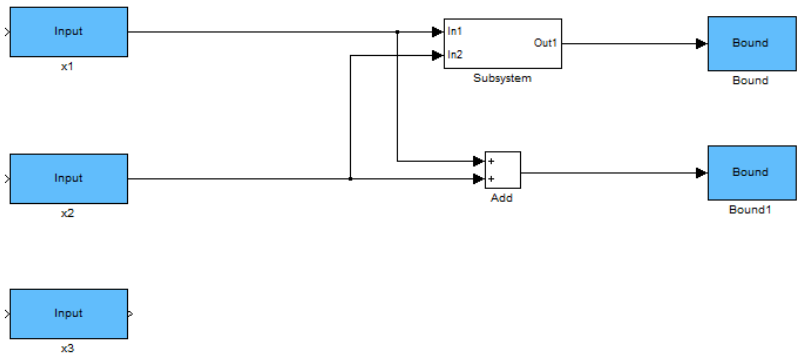


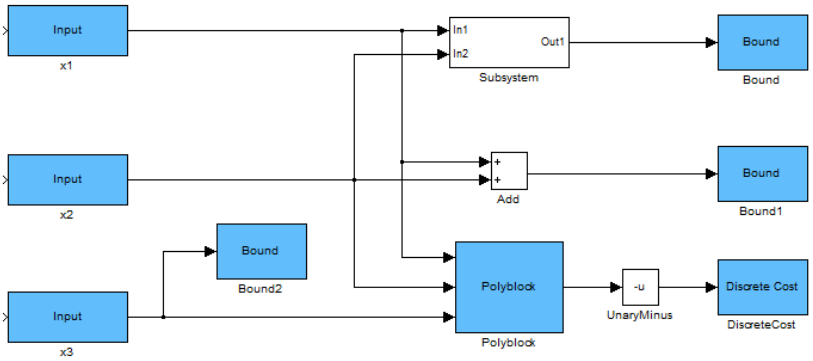
Step 3: Attach bound and cost blocks and set limits/time relevances





Repeat steps 2 and 3 as necessary





Calling BLOM

1. Always remember to run `BLOM_addpath` to add all the BLOM related files into your path
2. Create model in simulink
3. `BLOM_SetDataLogging('ModelName')`
4. `ModelSpec = BLOM_ExtractModel('ModelName', #timesteps)`
5. `[RunResults ResultsVec] = BLOM_RunModel(ModelSpec)`
6. `[OptGuess ExtVars InitialStates ] = BLOM_SplitResults(ModelSpec,RunResults)`
7. `SolverStruct = BLOM_ExportToSolver(ModelSpec,'Solver')`
8. `SolverStructData = BLOM_SetProblemData(SolverStruct,ModelSpec,OptGuess, ExtVars, InitialStates)`
9. `SolverResult = BLOM_RunSolver(SolverStructData,ModelSpec)`

Using Externals: Items 7-9 can be run in a loop using outputs from `SolverResult` to populate `OptGuess` and `InitialStates` in subsequent iterations. `OptGuess`, `ExtVars`, and `InitialStates` can all be filled in from the command line (e.g. `ExtVars.x1=5`, and `OptGuess=SolverResult`)

Optimizing Your Model

- Use fewer blocks. Outputs of blocks (with the exception of subsystems, from/goto tags, mux/demux) represent variables. Having fewer blocks and therefore fewer variables allows for faster computation.
- Switch to polyblocks. Converting groups of mathematical operations into polyblocks can also reduce the number of variables
- For polyblocks with sparse entries, create matrices using Matlab function sparse. This reduces memory storage and computations are optimized within Matlab.

Currently Supported Simulink Blocks

- Sum, Add, Subtract
- Product, Multiply, Divide
- Gain
- Unary Minus
- Bias
- Math
  - square
  - sqrt
  - reciprocal
  - exp
  - 10^u
  - log
  - log10
  - magnitude^2 (Reals only)
  - 1/sqrt, rsqrt
  - hypot
- Trigonometry
  - sin
  - cos
  - tan
  - asin
  - acos
  - atan
  - sincos
- Polynomial
- Constant
- Unit Delay
- Subsystem
- From, Goto
- Mux, Demux