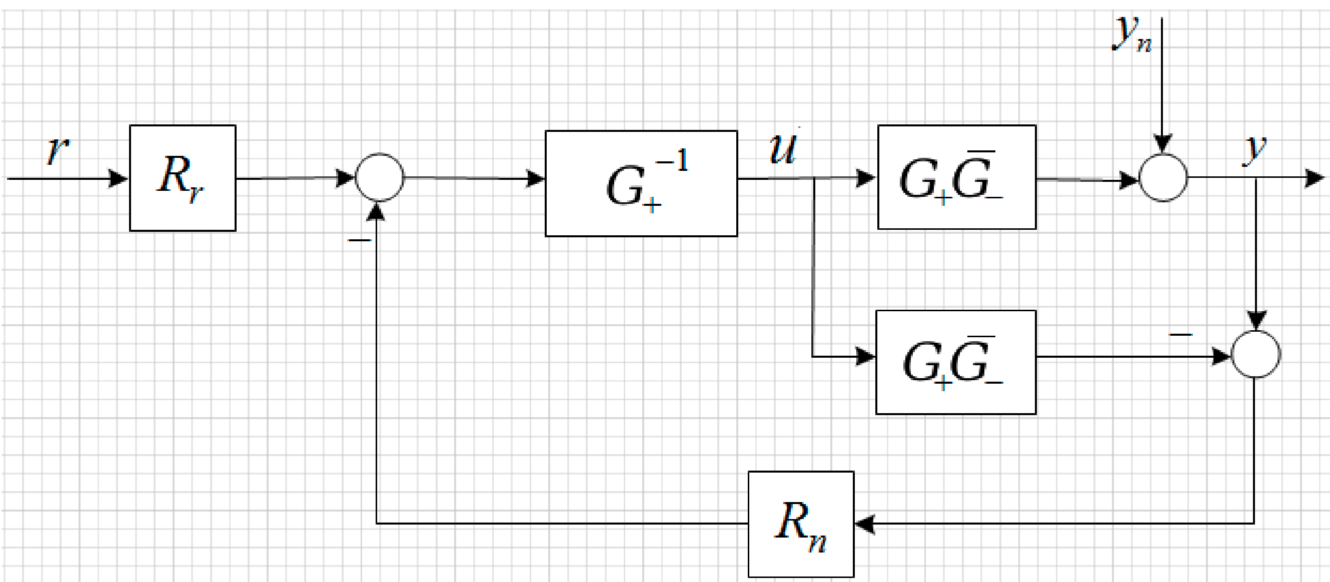
Youla (discrete)

About the program:

The program demonstrates the operation of the discrete Youla control system. The parameters of the process and of the controller can be set.
The program shows the time response of the output signal and of the controller output for step reference signal and shifted disturbance signals on the right side figures.

About the simulation:

The simulation is executed according to the block diagram below.



Notations:

r - reference signal
u - control signal
y - output signal
yn - output disturbance
Rr - reference signal filter
Rn - disturbance filter
$G+^{-1}$ - pulse transfer function of the controller
G+G- (upper) pulse transfer function of the process
G+G- (lower) pulse transfer function of the model of the process

How to use the program

The Process is given at the left side of the screen. The new process is activated by pressing the “Set Parameters” button. The new figure appears pressing the “Draw” button.

The process is defined by its pulse transfer function in numerator/denominator form, where the elements of the polynomials are given in decreasing order of the powers, preferably separated by commas. E.g. “ 1,4,4 ” represents the polynomial »z^2+4z+4« . The program can handle brackets, e.g. the previous polynomial can be given also in the following form: „(1,2)(1,2)”.

The parameters of the controller are set in the “Controller” area. The input form is the same as described for the Process.

Below this the dead time, the target value, the graph length and the simulation time step can be set by sliders. The minimum/maximum values of the last two values depend on each other. This is applied to avoid a situation when using the sliders the given values would increase the computation demand of the simulation in such an extent what would make impossible the running of the program.

Deadtime: delay of the control signal
Target: the reference value of the output signal
Graph length: length of the drawn graph – its maximum value along the X axis
Timestep: simulation step

It is possible to add disturbance to the output of the process and also a stochastic noise. It is possible to apply also input disturbance. The initial point, the duration and the strength of these signals can be given (the length of the stochastic signal is infinity). The values of the sliders can move between 0 and 1, where 0 means the beginning of the graph and 1 denotes its end. Strength of 1 means the value of the target signal.

By “Using Textfields as input” button the input values can be given accurately in the textboxes.
ATTENTION: giving the values in the textboxes the values are not restricted

EXAMPLES

1. Example

The pulse transfer function of the process is

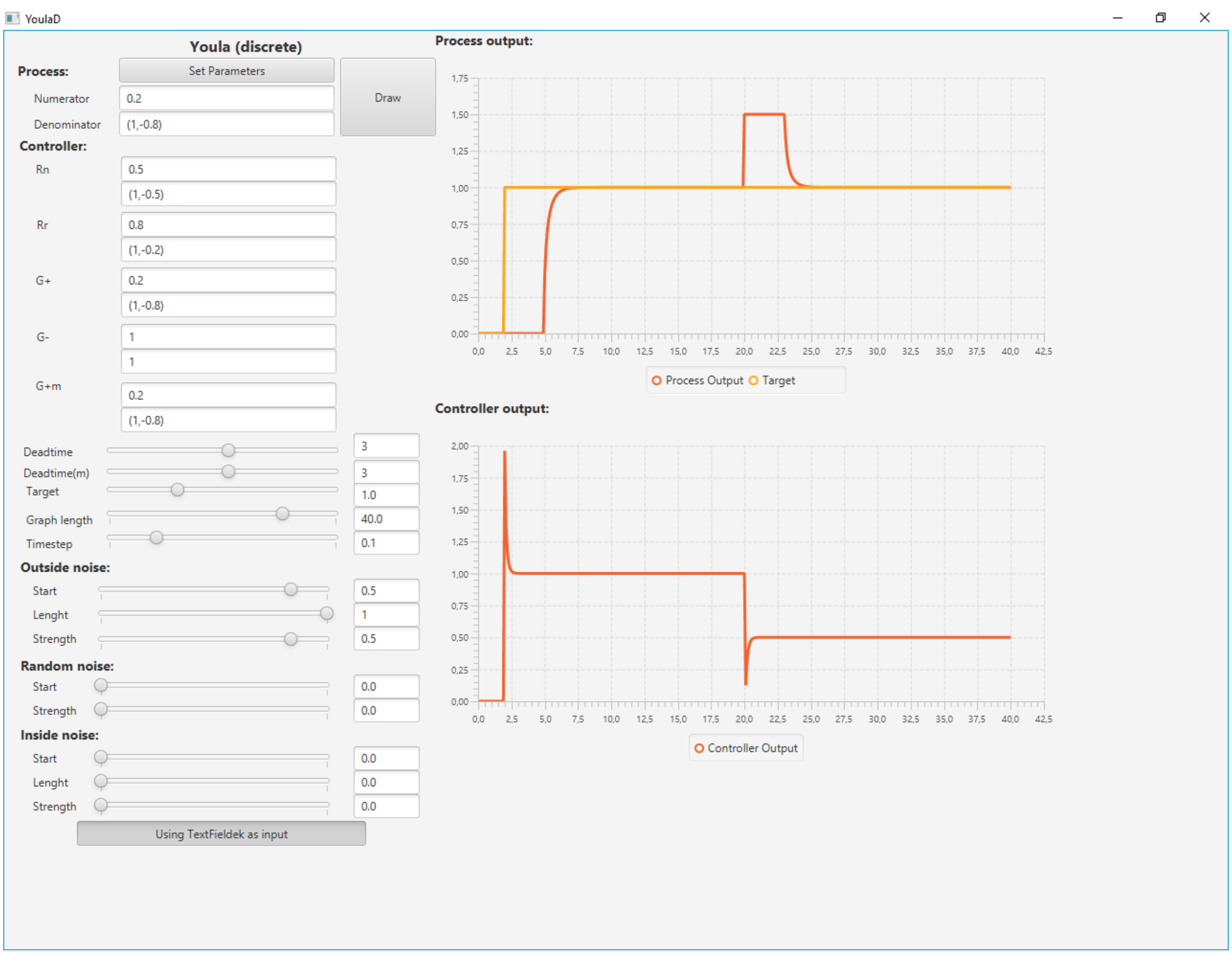
$$G(z)=\frac{0.2}{z-0.8},$$

The pulse transfer functions of the filters: $R_n(z)=\frac{0.5}{z-0.5}$; $R_r(z)=\frac{0.8}{z-0.2}$.

The pulse transfer function of the process can be cancelled: $G=G_+$; $G_-=1$.

The dead time is 10 times of the sampling time.

The figure below shows the behaviour of the control system. The output signal tracks the step reference signal and eliminates the effect of the output disturbance. The control signal is also shown. By changing a bit the parameters of the model there is a possibility to observe the effect of plant/model mismatch.



2. Example

The transfer function of the continuous process:

$$P(s)=\frac{1}{(1+5s)(1+10s)}e^{-30s}.$$

The sampling time is 1 sec.
The pulse transfer function of the process is

$$G(z)=\frac{0.0090559z+0.0082}{(z-0.90485)(z-0.8187)}z^{-30}$$

It is separated to the non cancellable component

$$G_-(z)=\frac{z+0.9048}{1.9048z},$$

and the cancellable component

$$G_+(z)=\frac{0.0090559\cdot 1.9048}{\left(1-0.90485z^{-1}\right)\left(1-0.8187z^{-1}\right)}=\frac{0.0172z^2}{(z-0.9048)(z-0.8187)}$$

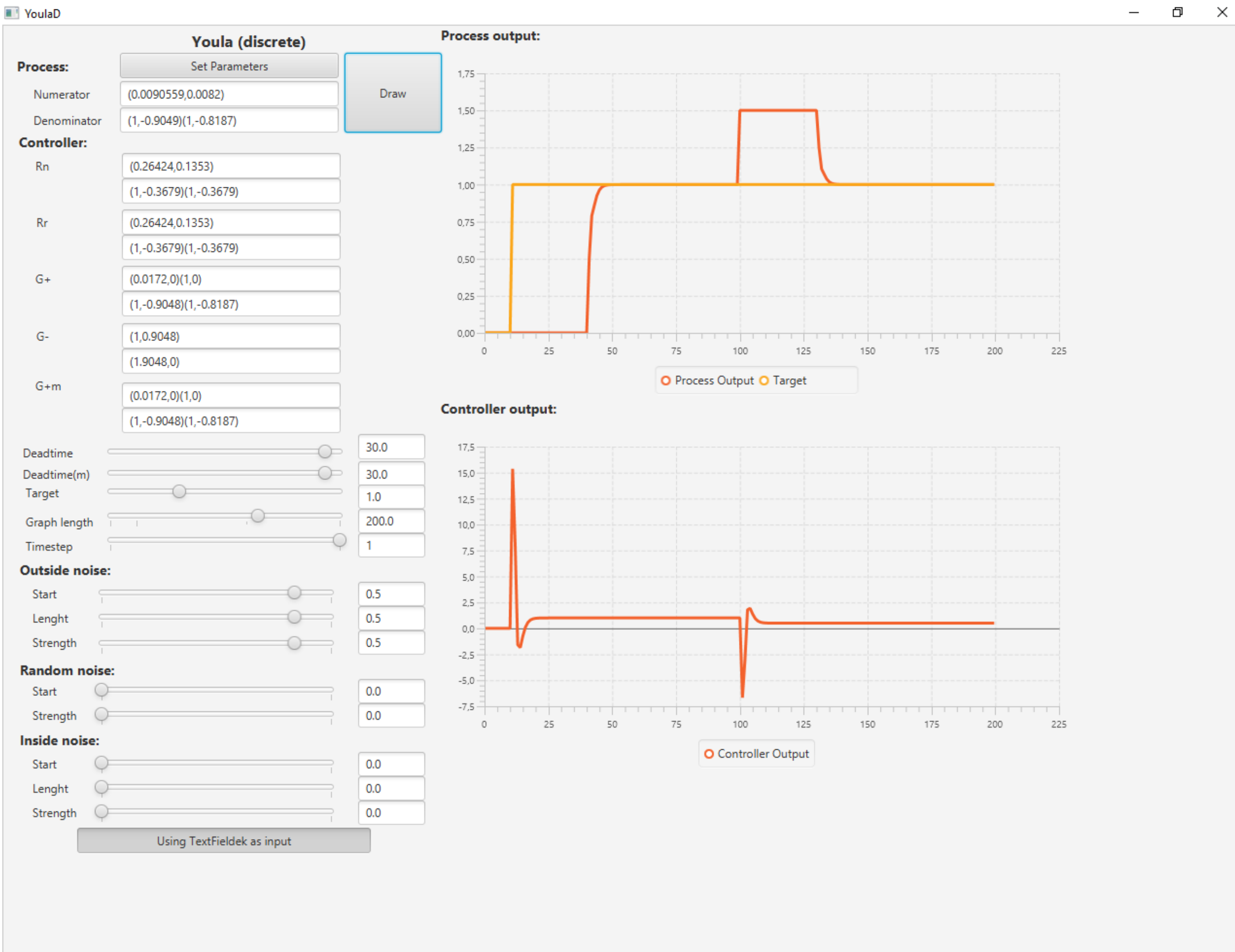
The pulse transfer functions of the filters are obtained by sampling the continuous filters of transfer function

$$R_r(s)=R_n(s)=\frac{1}{(1+s)^2}$$

The pulse transfer function of the filters is

$$R_\mathrm{r}(z)=R_\mathrm{n}(z)=\frac{0.26424z+0.1353}{(z-0.3679)^2}$$

The figure below shows the setting of the parameters and the time response of the system for step reference signal and for a shifted step output disturbance. The control signal is also shown. By changing a bit the parameters of the model there is a possibility to observe the effect of plant/model mismatch.


YoulaD
Youla (discrete)
Process:
Set Parameters
Draw
Numerator
(0.0090559,0.0082)
Denominator
(1,-0.9049)(1,-0.8187)
Controller:
Rn
(0.26424,0.1353)
(1,-0.3679)(1,-0.3679)
Rr
(0.26424,0.1353)
(1,-0.3679)(1,-0.3679)
G+
(0.0172,0)(1,0)
(1,-0.9048)(1,-0.8187)
G-
(1,0.9048)
(1.9048,0)
G+m
(0.0172,0)(1,0)
(1,-0.9048)(1,-0.8187)
Deadtime
30.0
Deadtime(m)
30.0
Target
1.0
Graph length
200.0
Timestep
1
Outside noise:
Start
0.5
Lenght
0.5
Strength
0.5
Random noise:
Start
0.0
Strength
0.0
Inside noise:
Start
0.0
Lenght
0.0
Strength
0.0
Using TextFieldek as input
Process output:
Process Output
Target
Controller output:
Controller Output