

Data treatment models for dynamic simulation: application to sensor models

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Scope

1. Introduction
2. Data treatment models
3. Sensor models
4. Examples
5. Conclusion



2



1. Introduction



Need to improve/optimize system
performance in WWTP
Modeling is one approach



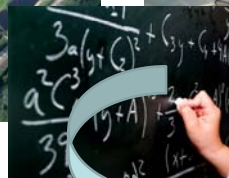
1. Introduction



Process
engineer

Modeler

Operator

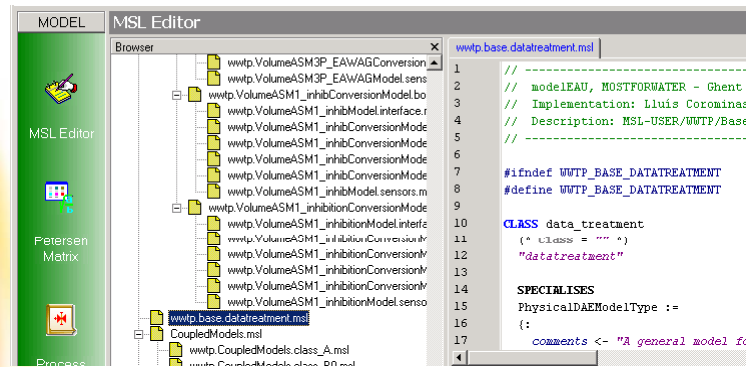


Dynamic models

Need to make data
treatment (e.g. adding
realism to the signals,
filtering, data analysis...)

2. Data treatment models

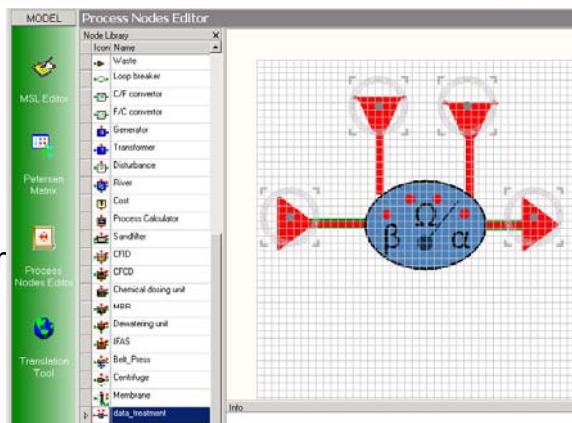
New class: *Data treatment*



2. Data treatment models

New node:

Data from m

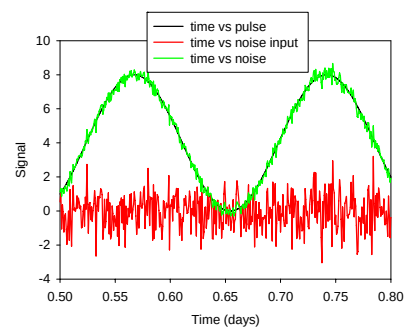
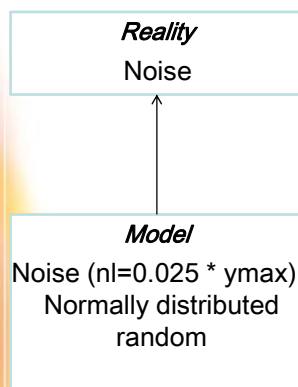


2. Data treatment models

New classes:

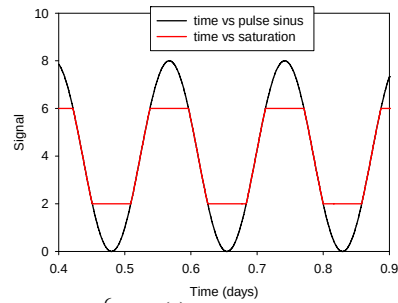
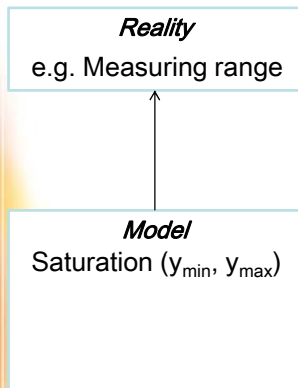
- Noise
- Saturation
- Sample and hold
- First order response
- Delay

2. Data treatment models



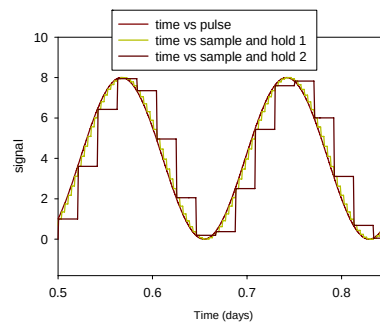
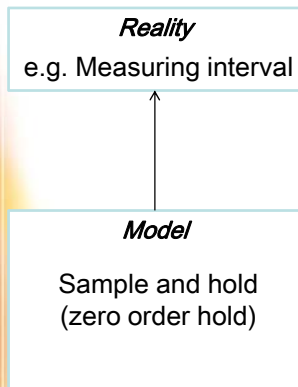
$$y(t) = u(t) + \text{noise}(t) \cdot \text{Noise_level} \cdot y_{\max}$$

2. Data treatment models



$$y(t) = \begin{cases} u(t) & y_{\min} \leq u(t) \leq y_{\max} \\ y_{\max} & u(t) > y_{\max} \\ y_{\min} & u(t) < y_{\min} \end{cases}$$

2. Data treatment models



$$y(t) = u(t_{\text{sample}}) \quad t_{\text{sample}} = \text{floor}(t / T_{\text{interval}})$$

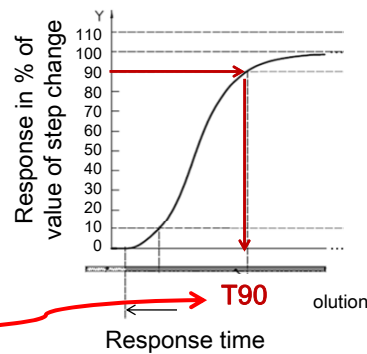
2. Data treatment models

Reality
e.g. Resp time, filter

Model
Linear transfer function

$$G_s(s) = \frac{y(s)}{u(s)} = \left(\frac{1}{1 + \text{Tau} \cdot s} \right)^n$$

From the 15839 ISO standard

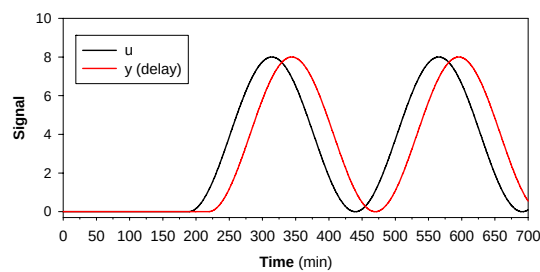


2. Data treatment models

Reality
Delay

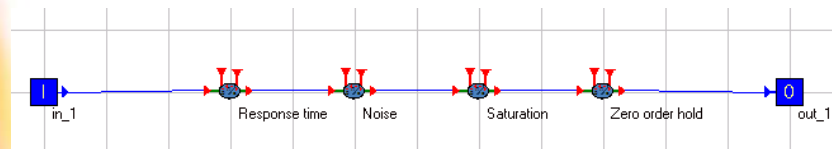
Model

$$y(t) = u(t - t_{\text{delay}})$$



2. Data treatment models (coupling)

- Flexibility to combine and couple different data treatment models



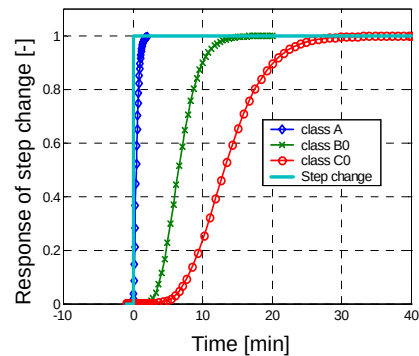
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3. Sensor models - classification

According to Rieger et al. (2003)

Sensor classes	Response time [min]	Measuring interval [min]
Class A	1	0
Class B ₀	10	0
Class B ₁	10	5
Class C ₀	20	0
Class C ₁	20	5
Class D	-	30



Rieger, L., Alex, J., Winkler, S., Boehler, M., Thomann, M., & Siegrist, H. (2003). Progress in sensor technology - progress in process control? Part I: Sensor property investigation and classification. *Water Science and Technology*, 47(2), 103-112.

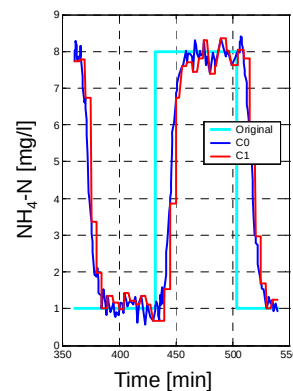
15



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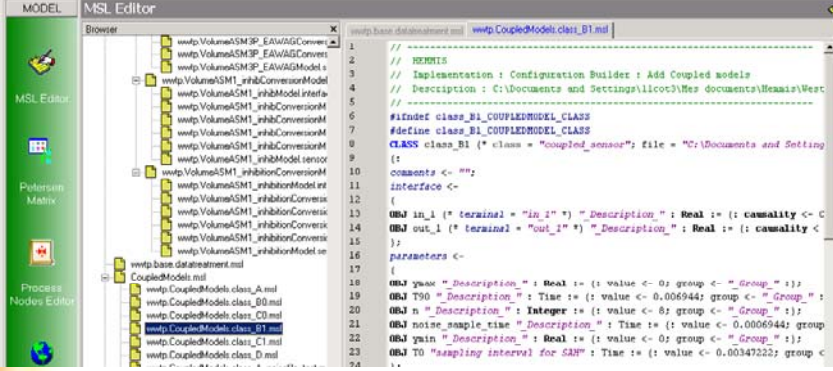


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16



3. Sensor models - classification



```

1 //
2 //
3 // REPRESENTATION : Configuration Builder : Add Coupled models
4 // Description : C:\Documents and Settings\lucos3\Mes documents\lucos3\West
5 //
6 #ifndef class_B1_COUPLEDMODEL_CLASS
7 #define class_B1_COUPLEDMODEL_CLASS
8 CLASS class_B1 ("class = "coupled_sensor"; file = "C:\Documents and Setting
9 {
10 comments <- "";
11 interface <-
12 {
13   OBJ in_1 ("terminal = "in_1" " " "Description" : Real := ( : causality <- C
14   OBJ out_1 ("terminal = "out_1" " " "Description" : Real := ( : causality <
15   };
16 parameters <-
17 {
18   OBJ ysize "Description" : Real := ( : value <- 0; group <- "Group" : );
19   OBJ T90 "Description" : Time := ( : value <- 0.006944; group <- "Group" :
20   OBJ n "Description" : Integer := ( : value <- 8; group <- "Group" : );
21   OBJ noise_sample_time "Description" : Time := ( : value <- 0.0006944; group
22   OBJ ymin "Description" : Real := ( : value <- 0; group <- "Group" : );
23   OBJ T0 "sampling interval for SAN" : Time := ( : value <- 0.00347222; group <
24   };

```

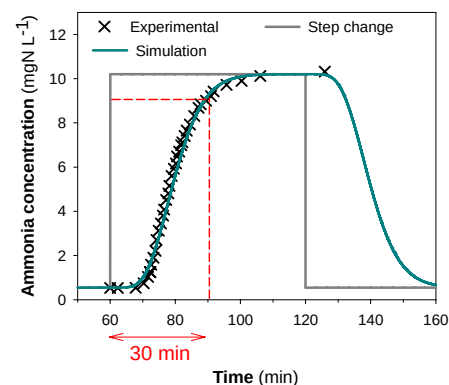
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17

modelEAW

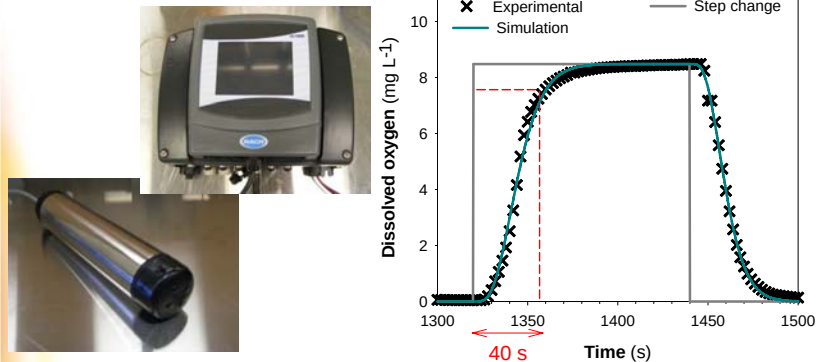
4. Examples (modeling response time)

■ Ammonia sensor

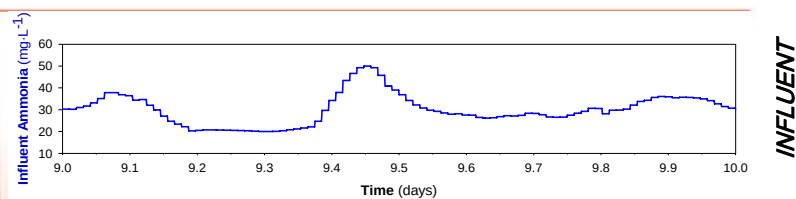


4. Examples (modeling response time)

■ DO sensor

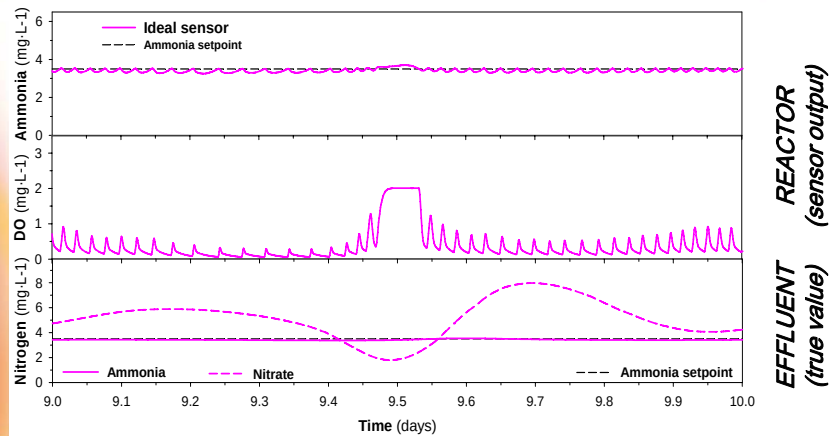


4. Examples (dynamic simulations)

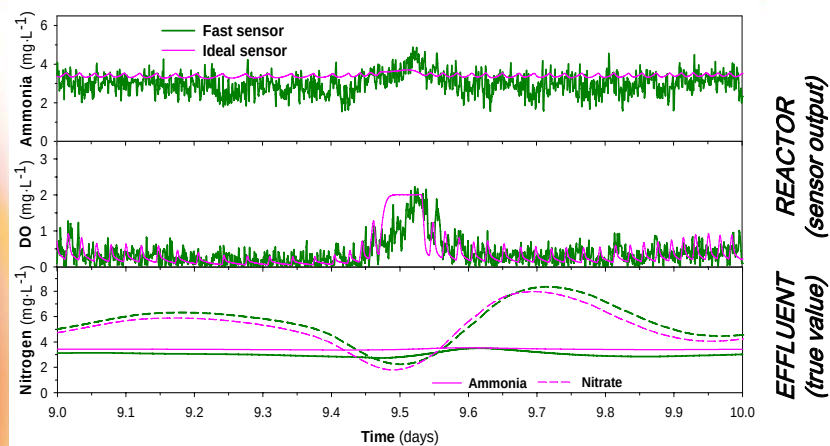


Lagacé E., Corominas LI., Vanrolleghem P.A. and Rieger L. (2009)
Improving design of measuring and control systems by introducing
sensor models into dynamic WWTP simulation.
ICA Newsletter, April 2009.

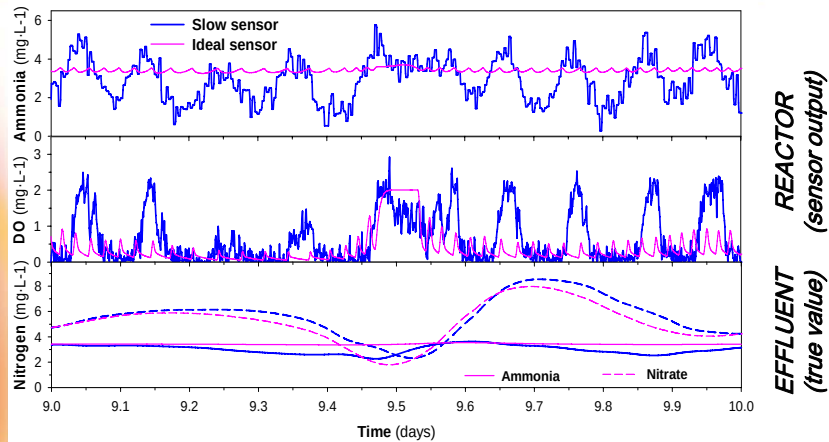
4. Examples (dynamic simulations)



4. Examples (dynamic simulations)



4. Examples (dynamic simulations)



5. Conclusions

- Data treatment models can now be used in dynamic simulations
 - Realistic sensor models
 - Realistic actuator models (start-up of pump, ...)
 - Data filtering
 - On-the-fly data analysis (e.g. moving average)

Acknowledgments



Canada Research Chair in
Water Quality Modeling



25

